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THE TURRET TELESCOPE.*

A New Form of Mounting Adapted to the Comfort of the Observer.

S. A. MITCHELL.†

The lot of a professional astronomer is no easy one. Several years ago, while at the Yerkes Observatory of the University of Chicago, the writer had abundant opportunity to learn what hardships it is sometimes necessary to endure in order to get astronomical observations. Many nights during the month of February, in a winter spent there, the thermometer was below zero; and on one particular night, while Professor Barnard was working with the 40-inch, and the writer with the 12-inch, the temperature dropped as low as 26 degrees below zero, Fahrenheit! And on this night, each of us worked for more than twelve hours! About three o'clock in the morning, work was interrupted by a sudden snow squall coming from a clear sky. This was caused by the freezing of the moisture in a passing cloud; and when this passed, the sky was brilliantly clear till morning. It is probably needless to add that the coming of the dawn was watched with a great deal of rejoicing. And though it is more than ten years since that night, the impression of it is as vivid as ever.

Those not familiar with the workings of an observatory will ask why it is not possible to keep warm by heating the building. Those who have ever seen the average observatory do not ask such a question, for they realize that the telescope is placed under a dome, capable of rotating, with an opening or slit in the roof through which the telescope looks out to the sky. If the dome were heated, how long would this heat remain when the

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slit in the dome was opened? And while the heated air was rushing out, the air in front of the telescope lens would be in violent commotion, and the "seeing" would be very bad. Ordinarily, the seeing is better when the temperature within and without the dome is the same. So that if it is a cold night in winter, there is no way for the astronomer to be comfortable; he must work in the cold—and be cold. And it is unfortunate, too, for the astronomer's work that the long nights come in the chilly winter, while the short ones come in the comfortable summer.

One must have a great love for astronomy and be gifted with wonderful enthusiasm to make a successful observer, for the disappointments of bad weather and poor seeing, and the rigors of the winter weather would deter any but the most ardent. If one is a professional astronomer, he puts up with the bodily tortures it is necessary to endure, for he has sufficient enthusiasm for his work. If one is an amateur, the enthusiasm of the beginner soon dwindles away; when it is discovered that it is necessary to be uncomfortable in order to gain a knowledge of astronomy.

It would be a great boon to both professional and amateur, if the mounting of the telescope could be so changed that the observer could be left in comfort in a warmer room. The standard form of erecting the telescope, known as the "equatorial mounting, is placed ordinarily under a semi-circular dome, the equatorial form being necessary in order to be able to neutralize the rotation of the earth by a motion of the telescope about its polar axis. This standard form has come to its greatest completeness in the Lick and Yerkes telescopes designed by Warner and Swasey of Cleveland.

Many attempts have been made to keep the observer in a heated room, the most famous of which has been the *equatorial coudé*, or elbow-telescope of the Paris Observatory. With this form, two extra reflections from plane mirrors are necessary. These mirrors, which must be much larger than the objective, add greatly to the expense of the telescope, and largely decrease its optical efficiency. The well-known excellent photographs of the moon taken at Paris with this instrument are abundant proof that there are no serious drawbacks to this form of mounting. While measuring with such an instrument, the observer sits in a comfortable position in a heated room, and looks in a fixed direction down the polar axis of the telescope. All observers know that their own measures are most accurate

when they are most comfortable, so that the quality of the work as well as the quantity would be improved if the astronomer could be kept in a heated room.

Undoubtedly, the most promising form of all mountings which keep the observer housed is the "turret telescope" of Mr. James Hartness, of Springfield, Vt. Mr. Hartness, though making no pretensions to being an astronomer, is the efficient president of the Jones and Lamson Machine Company. The mounting was entirely designed by him, and most of the work done in his own shop in Springfield. At the invitation of the inventor, the writer went to Springfield and saw the instrument, and can speak in the highest terms of it.

MR. HARTNESS' TURRET TELESCOPE AS SEEN FROM THE NORTHEAST.

In this new instrument, the objective has the diameter of ten inches, one additional reflection only is necessary, introduced by a diagonal prism near the eye end. All optical parts are by Brashear.

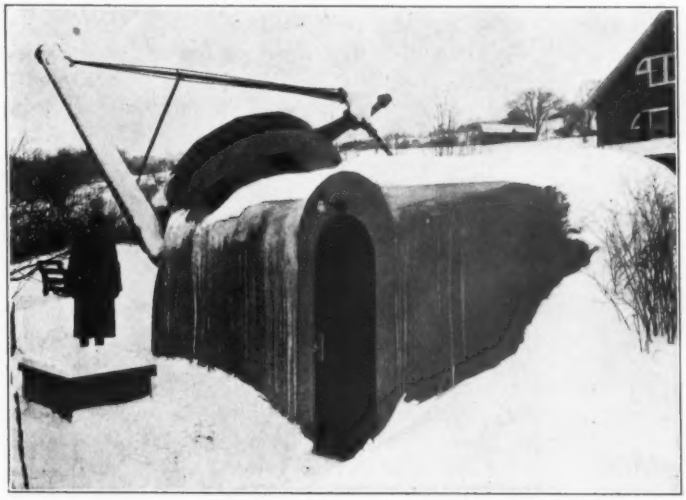
Of polar axis there is none, its purpose being accomplished by a turret revolving in the plane of the equator. To the turret is fixed the declination axis about which the telescope revolves, and where the declination axis cuts the optical axis of the telescope there is located a totally reflecting prism turning the beam through 90 degrees. The observer sits in a comfortable

position facing toward the north, and is obliged to change his position very slightly as the telescope follows the object. He may see what the weather is like by looking out through several windows in the turret near his head. There is no dome to shelter the objective, in fact, this is left free in the open air. The average professional astronomer would look askance at leaving a valuable objective unprotected from the elements other than by a cap. The cap on the telescope of Mr. Hartness fits very snugly, and though the objective had not been touched for two months before the time the writer saw it, there was hardly a trace of dust to be seen.

LOOKING WEST

From Mr. Hartness' house, the observatory is approached through a tunnel 240 feet in length and 9 feet high, the telescope being on the brow of a hill. The first room entered is a comfortable office. Through a door and up a few steps; one is in the observatory. Up a few more steps, and one seats himself at the eye-end of the telescope. A circular ring about the eye-piece is the graduated declination circle of 24 inches diameter, and on this by means of a convenient handle is readily turned off the declination. Around the edge of the turret inside is the hour circle of 48 inches in diameter. This ring of four inches wide and three-fourths inch thick may be moved by hand

and set to the right ascension of the star to be observed. The whole turret is now turned in right ascension by means of an electric motor, and when the sidereal time is set off, the quick motion is shut off and a slow motion substituted in order to drive the telescope. The writer set on several stars with the greatest of ease.



LOOKING NORTHEAST IN WINTER.
A Tunnel 240 feet long connects the Observatory with the House.

Regarding the mechanical precision of this form of telescope, one very naturally asks about the reliability of the turret to maintain the plane of the equator, and permit of rotation in this plane. These features are accomplished by providing the turret with a perfectly planed surface on its under side, and a truly circular track. It also requires in the building a stable mounting for rolls on which the turret rests. In fact, there are two sets of rolls; one set, on which the flat face of the turret rests, keeps it constant in direction while the circular part of the turret bears on the other set of rolls, and upon motion being imparted to these by the electric motor the telescope is revolved. It seems to the writer that the excellent precision of modern machine-shop work will insure for this form of telescope all the accuracy necessary.

This instrument is decidedly superior in optical efficiency to any *Coudé* form of mounting or any horizontal or other form of telescope fed by a coelostat or siderostat. In fact, is practic-

ally as efficient as the standard equatorial with a diagonal eye-piece, for this new telescope might be briefly described as a mounting in which the telescope revolves about its diagonal eye-piece. Consequently it seems that no objection can be made to the optical arrangements. The mechanical parts have a precision seemingly quite as great as the ordinary equatorial mounting. On the other hand this new mounting is in many respects decidedly superior to the standard form.

Disregarding for the time being the temperature of the observing room, the observer with the turret telescope should measure more quickly and more accurately with a micrometer, for the observer would always be in a comfortable position, and no time would be wasted in adjusting the height of the observing chain, a star near the zenith being as easily observed as one near the horizon. For photographic or spectrographic work the new form of telescope should be also superior, for the eye-piece being firmly held in the turret, it would not be necessary to alter the counterweights when camera or spectrograph are substituted instead of micrometer. The added advantage of a comfortable room would seem to make this new telescope of Mr. Hartness the ideal mounting.

In fact the only objection that seems possible to make against it is that it is an open air telescope, and that it would vibrate badly from the winds. The ordinary telescope is sheltered by the dome except when the wind blows through the slit, and then by the use of wind screens, as at the Yerkes Observatory, the force of the wind may be minimized. It must be remembered, however, that the turret telescope is rigidly fixed at the eye end, and braced at the objective. Mr. Hartness was appealed to by the writer regarding this point, and has stated that the wind has little effect, that a rigid test of the instrument will be given, and then, if necessary, it will be easily possible to shelter the tube entirely from the wind.

The cost of this new form of telescope would be greater than that of the ordinary equatorial mounting. But no dome with running gear is necessary for it, so that the cost of building observatory and telescope together would not differ much in the two cases. If a demand were created for turret telescopes, their cost would gradually decrease.

Taken altogether, the invention of the turret telescope by Mr. Hartness is one of the biggest improvements in mountings that has taken place for a long time.

THE FORM OF THE EARTH.

WILLIAM THAYER JORDAN.

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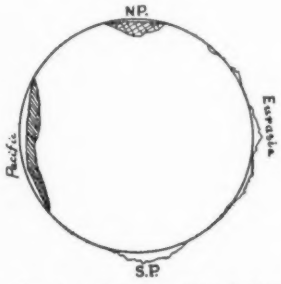
It was long ago pointed out that there must be, "Some excess of matter in the solid part of the earth between the ocean-basins and the earth's center." The deflection of the plumb-line toward the sea in many cases shows that the density of crust beneath the continents is less than that of the crust beneath the ocean basins. As is the case of the great Indian survey which shows that, "The great accumulated masses of mountain chains correspond to subterranean mass diminution." In other words, the crust here is lighter.

Supposing our spheroid to be thus composed, and to be acted upon by the cosmic forces, gravity, and the centrifugal force; or, expressed more fully, the self gravity of the earth, the combined action of the gravitational forces of the sun and moon, and the centrifugal force, the result would be body-tides in the earth commensurate with these forces.



Section showing the relation between the areas of depression and the elevated areas.
The shaded portions indicate the supposed heavier masses underlying the ocean deeps.

Returning to the relation of the oceans to the opposite lying continents which we have already discussed, we saw that under the action of the earth's gravity the heaviest bodies composing the crust would sink, and ultimately reach great depths, thus causing the deeps, or antiplateaus, of the oceanbasins; and also that vastly larger areas of lighter, yet relatively heavy material, would sink with them to lesser depths. These in the main would constitute the ocean beds; and at the same time, as a result of this movement of the heavier masses changing proportionally the center of gravity, and also by the push and pressure, the opposite portions where the crust was not too heavy would be pushed up, thus forming the continental areas. As the heavier areas sank, the inflow of water added its weight to the sinking mass; and to a pro-

portional degree relieved the pressure upon the stationary or rising areas from which it flowed. Thus the water flowing into these depressions increased the effects due to the primal differences in specific gravity of certain portions of the crust. The first differences may not have been so very great; but once started, this self-increasing character of these processes may from small beginnings have developed the ocean basins and continental masses. The "deeps" in the ocean basins of today may be the original areas of depression, and thus the ocean-basins and the resultant continental masses would be formed, at the same time.

Here we have an explanation of the fact that the continental masses and the ocean-basins lie opposite each other ;which was the first marked characteristic of the earth's surface that we noted.

Now further let us consider that this world-wide and simultaneous movement of the earth's crust would give rise to vast and irregular areas between the sinking ocean basins and the rising continents, where the crust would be subject to the pull of the sinking masses and the tug of the up-pushed continents; and, too, the whole crust, whether rising or sinking, would be subject to the strain resulting from the pull of gravity adjusting it to the interior, as the earth's whole mass contracted from its constant loss of heat. And here comes into play the great determining factor as to the general arrangement of these lines and areas of stress which are to form the shore lines of the nascent ocean-basins and continents, and direct the general trend of the great world-ridges. This determinant is the body-tide resulting from the combined gravitational effect of the earth the sun and the moon, and the earth's centrifugal force; the body tides which in two great waves daily sweep around the earth; and have done so from the very earliest geologic ages.

If, as is generally supposed, in these earlier ages the crust was more plastic than now, by so much the more, must these body-tides have been greater and more effective than at present. And if, as it is estimated that at the present time, the maximum body-tides at the equator amount to nineteen and a half inches, how much greater must they have been in the earlier eons!

Now, if from any cause a cooling and contracting body were thrown into a regular and continuous series of waves, the resulting folding and wrinkling would of necessity follow a

course largely determined by these waves. To repeat, it is evident that as the earth shrinks from cooling, its crust by so much becomes too large to fit the reduced spheroid; and under the stress of gravity it is constantly held close to the shrinking interior and becomes folded and wrinkled, pushed up into great ridges or mountain ranges with corresponding concavities. All this goes on at the same time with the sinking of the ocean-basins and the rising of the continents. Across and through all the earth, while it is under the stress and pull of these forces, plays the unceasing influence of the masses of the sun and moon; showing itself, as we have seen, in the body-tides, greater, and we need remember all the more effective in the earlier ages, if the crust were more plastic.

At mid-summer and mid-winter these body-tides are earth-waves whose crests are great-circles passing through the poles; and as the earth moves forward in its orbit these wave-crests swing until at the equinoxes, at new and full moon, they form great circles tangent to the polar circles. These tangent circles mark the maximum divergence of these wave-crests and body-tides of the earth from the lines of longitude. The regular, twice daily, pull and stress caused by these body-tides, beginning with the birth of the earth; and then twice yearly through all the long geologic eons, coming to the invariable limit, seems to be the sufficient cause determining the almost universal approximation of the continental shore lines and mountain ranges and allied phenomena to lines tangent to the Polar Circles. In a certain way we might almost call these mountain ranges and shore lines petrified tidal waves.

As a perhaps minor matter, yet corroborating the above conclusion, let us note that, of course, the force of these body-tides diminish as the poles are approached, and hence we find, as we might expect, that all signs of their influence usually disappear near the Polar Circles; that the coast lines, with the exception of Greenland, are all approximately parallel to lines of latitude; and that the mountains and islands appear to be more in groups than in ranges; and that at the south pole there is a range of mountains, that suggests a continuation of a South American coastline, running, according to the reports of Capt. Amundsen, from the coast to the poles itself.

Perhaps it may be as well here to call attention more fully to the predominating great-circles, tangent to the arctic circles at approximately 0° and 180° longitude, the great circles which determine, as before pointed out, the coast lines, mountain

ranges, and submarine ridges and hollows of North and South America, eastern Asia, the Malay Peninsula, and connected sub-marine ridges. The importance of these great lines can be best appreciated by following them as approximately marked by the dot and dash lines on the chart. The question at once arises as to the cause that determines these tangent points. This would appear to be the influence of the deeps and great ocean-basins upon the body-tides. And this can best be shown by turning again to the chart. The Pacific ocean bed is estimated to be as large as that of all the other oceans taken together; and further we will see that as a whole this basin and its deeps are approximately symmetrical to a line of longitude of about 170° west. Within ten degrees of this at both Polar circles the great circles are tangent, which approximate the great continental shore lines and world-ridges. A recent writer in La Nature says, "It would seem probable that the vast line of deep pits, almost in the plane of the meridian of Greenwich is an ancient feature of our globe's structure." Can we not say, a most ancient feature, and that here lie the heaviest masses, the deepest and oldest seas? We also find this same condition apparently producing similar results in the other ocean basins, but, of course, on a smaller and less striking scale. These deeper and denser masses determine the points of tangency by the resistance they offered to these tidal body waves,—all this is in a manner similar to the effect of land masses on the ocean tides.

And now to sum up the matter, while we nowhere find more than an approximation to the law of tangency, with, of course, many exceptions, yet the totality of the evidence presented by these facts must force the conviction that it is the law of arrangement of mountain and shore lines; that we have back of all this some cosmic force constantly working through all the long geologic eons; and that this force is gravity, the resultant of the combined masses of the earth, the sun, and the moon; and the centrifugal force arising from the revolution of the earth on its axis; these producing the body-tides, as we have already indicated.

In conclusion, it may be noted, that after considering the above forces and processes of world making there does not seem to be much need of the so-called tetrahedral theory to explain the form of the earth.

Again if the foregoing is true, it would seem, as we have already noticed, to be against the theory suggested by some

to explain the changes of climate in the glacial epochs, that there were great changes in the position of the earth's axis; for as the general positions of the great world masses and the general trend of the great world-ridges seem to have been fairly constant through all the geologic ages, it would seem that the axis has never changed more than a very slight degree from its present position. We may also observe that the theory advocated by the Rev. Osmond Fisher and Professor Sir George Darwin, that the moon was at one time thrown off from the earth, seems to be contradicted by the above facts.

For if this theory be true, and the separation occurred, then the moon came to be in its present place at so early a geologic age that no sign of its ever having been nearer than at present can be discovered in the existing shape of the earth, its continents, oceans and mountain ranges. But, if in the earlier formative geologic ages the earth were more plastic, then perhaps, the solar tides would have been powerful enough to have effected nearly all the results we see today; and the moon may have been captured later, and then in subsequent ages contributed its share toward developing the form of the earth. And further, instead of, as some have advocated, the basin of the Pacific being a cavity left by the thrown off moon, the sinking of this basin simply shows that there is more matter there, not less, or in other words denser, than where the continental areas have arisen. The advocates of this moon theory had better hunt for their missing link on the highlands of Asia rather than in the Pacific depths; but are not at all likely to find it anywhere.

It may perhaps be that the same play of cosmic forces are the causes of the markings seen on the moon, Mars, Venus and Mercury, that we have seen to be the probable cause of the markings of our own earth. And we see why the distribution of the elevated and depressed tracts upon the moon, and the lighter and darker areas upon Mars, if they can be so interpreted, are so unlike those of the earth; for the force of gravity, the centrifugal force, and the arrangement of the varying masses of differing specific gravity, and hence the resulting body tides, would be all of them entirely different. It would seem to be impossible that two planets could ever have the same, or in any way similar, arrangements of its areas of elevation and depression.

A study of the map of Mercury as prepared by the Lowell Observatory would suggest that the markings shown upon

the planet may have been caused by the solar tides wrinkling the contracting crust, in the long ages in which the planets period of revolution about its axis was not as it seems to be today, the same as its period of revolution about the sun. And, too, in these markings we may have a record of the planet's change of inclination of its axis to the plane of its orbit. The markings (and these seem to be the plainest) which are parallel to lines of longitude may be the result of wrinkling when in later ages the planet's axis had come to be, as it is now, perpendicular to its orbit; and the far more numerous, but as a rule not quite so distinct, markings perhaps we can refer to a time in the long prior ages when the axis was considerably inclined to the plane of its orbit. These markings are about equally made up of lines inclined to the right and to the left of the lines of longitude; and apparently all approximating to the same angle of inclination. That these markings are more regularly distributed over the planet's surface than the world-ridges are upon our own planet may be owing, perhaps, to a more homogeneous arrangement of matter in its crust.

Lowell in his Evolution of worlds says: "They seem to mark a globe sun-cracked, though they cannot probably be actual cracks." But whether elevations, depressions or cracks, they seem to follow the same law of cause and effect as the markings upon the earth.

But leaving the planets and coming back to our own earth, may we not have found in these cosmic forces an explanation of the form of the earth, and the periodic changes of geological climates most marked in the so-called Ice Ages, or Glacial Epochs?

ALPHA LYRÆ.

Like starry diamond sparkling bright and high,
The Harp's great beacon blazes mid the night,
An azure gem against an ebon sky
Where eastwardly the Swan-Cross twinkles white;
When Leo reigns and harvest time draws nigh,
And Sol forsakes his kingdom's northern height,
When sultry dog-days pass so slowly by,
Then, queenly Vega glitters on our sight.

CHARLES NEVERS HOLMES.

The Plymouth Inn.
Northampton, Mass.

THE DISTANCES OF THE STARS.*

HEBER D. CURTIS

The subject which I hope to treat in a rather popular fashion to-night is somewhat bewildering to astronomer and layman alike, because of the immensity of the quantities involved, and I shall try to make what I have to say sufficiently general in its character to avoid confusing unduly those not directly engaged in astronomical work with too great a mass of enormous figures. So I must, at the outset, beg the indulgence of the astronomers present if I attempt to make some points as clear as I may by the use of examples and illustrations which may seem to them rather elementary. On the other hand, it may be necessary also to refer occasionally to more technical matters, for which I must ask the temporary indulgence of those who, except for their interest in astronomy, do not belong to the class I have just named.

First, to define a term which we shall have frequent occasion to use,—just what do we mean by the parallax of a star?

The process of finding the distances of the stars, in its essentials, is exactly that used by a surveyor who desires to find the distance from his camp of some inaccessible mountain. In most such cases it would be absolutely impossible for the surveyor to measure the distance in the ordinary way with tape or chain, because of the roughness of the country intervening, or the absolute inaccessibility of the mountain peak. To determine, then, the distance of such an inaccessible object, the surveyor proceeds as follows (Fig. 1):—

From his camp at A he first measures off with his tape as accurately as possible to-distance to a second camp at B, so that from either station A or B he can see the other station and the peak whose distance he desires. Then setting up his theodolite at station A, he measures the angle A′ between station B and the mountain C; when this is done he goes to station B and similarly determines the angle B′ at that point between station A and the mountain. Since he has actually measured the length of his base line between the two stations, he now

* An illustrated popular lecture delivered before the Astronomical Society of the Pacific on July 20, 1911. Reprinted from *Publications from the Astronomical Society of the Pacific*, June-August, 1911.

knows one side and two angles of the triangle ABC and can find by a very simple calculation the lengths of the other two sides of this triangle, and the side from A to C is the distance he requires. Since the sum of the angles of a plane triangle is

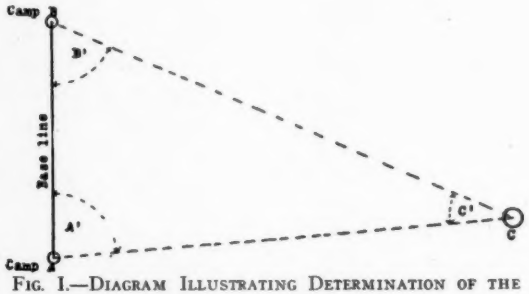


FIG. I.—DIAGRAM ILLUSTRATING DETERMINATION OF THE DISTANCE OF AN INACCESSIBLE OBJECT.

equal to two right angles, he could subtract the sum of angles A′ and B′ from 180° and obtain angle C′. This angle at the mountain, made by the chosen base line may be regarded as the parallax of the mountain, though, as a matter of fact, the surveyor seldom uses this term, preferring to reckon the distance AC directly in miles. But the astronomer has to do with distance so inconceivably great that a unit of a trillion miles is none too large, and finds it very convenient to speak of the parallax of a star—that is, the size of the angle C′—more frequently than he does of the actual distance.

The surveyor finds a base line of a few hundred yards in length sufficient for determining many distances, but sometimes for objects a long way off he will measure off a base line as long as possible, often several miles in length, for the longer the base line the more accurately he will be able to determine the distance of the remote object. But an enormously greater base line is required for the distances which obtain in astronomy. The nearest of the heavenly bodies to us is the moon, nearly two hundred and forty thousand miles away, and for the determination of this great distance the astronomer can still find a long enough base line on the earth. (Fig. II.) In this case let us assume that we have two observatories making observations on the position of the moon at the same time; the two observatories are quite well separated on the Earth, and because we know the positions of two observatories A and B we know the length of the base line from A to B. So

the astronomer can solve this great triangle with a base line several thousand miles long in much the same way as does the surveyor for a base line a few miles in length. Here again we may consider the angle C′ (which is the angle made at the

FIG. II.—DIAGRAM ILLUSTRATING DETERMINATION OF THE DISTANCE OF THE MOON.

moon by the distance between the two observatories) as the parallax of the moon, though the astronomer, for the sake of uniformity, always reduces this to the angle made by the semi-diameter of the earth as seen from the moon.

When we come to the distance of the stars, however, no base line on the earth is long enough, and we must search for something much greater. The earth in its orbit makes this base line for us and, enormous as it is, it is all too small for the purpose. (Fig. III.) If the position of a star in the sky be determined as accurately as possible in March, for example, and then again in September after an interval of six months, the earth will meanwhile have carried us around to the other side of the sun, one hundred and eighty-six million miles from the position in March. Then if a slight difference is found in the position of

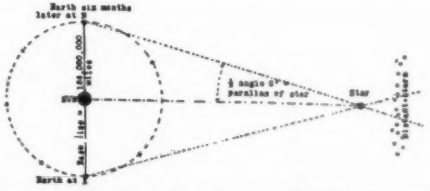


FIG. III.—DIAGRAM ILLUSTRATING DETERMINATION OF THE DISTANCE OF A STAR.

the star between the two observations we have determined the angle C′, and as we know the length of the base line from A to B we can determine the distance of the star. The parallax of a star, then, is the angle made at the star by the radius of the earth's orbit. If there were an astronomer on the star and he could see the earth (which would be impossible), the parallax of the star would be one half the small angle made by the earth moving from one side of its orbit to the other.

Put in another way, the parallax of a star means how big a line ninety-three million miles long would look when seen from the distance of the star. The slight shift in the position of the chosen star is determined from measures made to fainter and presumably much more distant stars, though this is somewhat of an assumption and not always true, giving rise occasionally to a *negative* result for the parallax, which would indicate that the chosen star is really farther away than the comparison stars used.

To determine this small shift in position is one of the most difficult, if not absolutely the most difficult problem in astronomy, and has taxed the utmost skill of astronomical science for three quarters of a century, with results which we must confess are very meager at best. Why? Because the stars are so infinitely distant that this small angle, the parallax, is for most of them vanishingly small. There is no star known whose parallax reaches one second of arc; a second of arc is less than one millionth of the distance around the circumference of a circle; on a circle three feet in diameter it is less than one ten-thousandth of an inch, and all the skill of instrument-makers can scarcely guarantee such accuracy in dividing a circle. Move the Golden Gate two hundred thousand miles away, and it would subtend one second of arc; a second of arc is the size a tennis ball would look if seen from a distance of eight miles; an ordinary man two hundred and fifty miles away, if we could see him at all, would be one second of arc high. Yet ninety-three million miles, the radius of the earth's orbit, looks smaller than this when seen from the very nearest of all the stars. *Alpha Centauri* in the southern heavens is, so far as we know, our nearest neighbor among the stars and has a parallax of three quarters of a second of arc; this translated into miles means that *Alpha Centauri* is nearly twenty-six trillion miles from us—twenty-six million times a million miles. It would be a difficult thing to determine whether a man one mile away were seventy-one or seventy-two inches high, to say nothing of attempting such a feat if he were two hundred and fifty miles away, and no one would be bold enough to say that we know the parallax of *Alpha Centauri* within one percent of the truth; yet an error of one percent in this vast distance would mean an uncertainty in the distance of over two hundred billion miles. It is, of course, futile to attempt to conceive of such enormous distances. Few of us have any very clear conception of what a distance of five miles really means; sea captains, surveyors,

and trained military men have some conception of larger distances, say of fifty to one hundred miles, but one million has very little meaning to any of us. Half a century ago, when curious wagers were frequently made in England, one English gentleman bet another five hundred pounds that it would be impossible to make one million strokes of the pen in a month; this means about one stroke a second, ten hours a day, for thirty days. The wager was won, but only by having doctors and attendants on hand during the last weeks to massage the almost worn-out wrist. So the distance to the sun, ninety-three million miles, has no real meaning. Yet *Alpha Centauri* is nearly three hundred thousand times as far away as the sun. The familiar and somewhat hackneyed illustrations give us no help. We are familiar with the statement that a lightning express, sixty miles an hour, day and night, year in, year out, would need one hundred and seventy-seven years to reach the sun, but this illustration leaves us no better off than we were before as far as the comprehension of even this relatively small astronomical distance is concerned.

So meaningless are these almost infinite distances that no attempt is ordinarily made by astronomers to express the distance of a star in miles. This is a unit far too small; even if we use the distance from the earth to the Sun as a unit we would have inconveniently large numbers. The astronomer ordinarily speaks of the distance of a star simply by mentioning its parallax; for instance, he will say that such and such a star has a parallax of seven hundredths of a second. Frequently, however, he expresses its distance by the use of a foot-rule longer than any of the relatively small distances afforded by our own solar system. Light travels at the rate of one hundred and eighty-six thousand miles a second, roughly a distance equal to seven times around the earth in one second of time. It takes light about eight minutes to reach us from the sun; and the foot-rule which the astronomer occasionally uses is the enormous distance, nearly six trillion miles, which light would traverse in one year. It would take light over four years to reach us from *Alpha Centauri*, so it is convenient to say that *Alpha Centauri* is four light-years away. Doubtless many of the fainter stars are at the very least one thousand light-years away; that is, if that light were blotted out to-night the world would not know of it for a thousand years.

Later I shall treat of more modern methods which have within the last few years given us a far better idea of the

average distances of the stars than we could ever hope to obtain by the older methods, but first will treat very briefly of the processes ordinarily used to determine the parallax of a star, which is nothing more nor less than finding its very slight shift in position as the earth moves from one side of its orbit to the other. The older methods used were those depending upon astronomical instruments which serve to measure the position of the stars with great accuracy—the meridian circle, the micrometer, and the heliometer. It would only confuse were I to attempt to describe the various sources of error which must be allowed for as far as possible. Suffice it to say that so minute are the quantities to be measured that a most searching analysis must be made of all the errors unavoidably inherent in the instruments and the measures made with them.

The errors of the carefully cut screws and the delicately divided scales must be investigated, also the personal errors of the observer, the conditions under which the observations are made must be kept the same as far as possible; errors have been found due even to the variation on the position of the stars from the meridian; when all these are allowed for the difference in the seasons six months apart at which the observations must be made may give rise to minute errors which are practically impossible to eradicate entirely. Of the older visual methods, doubtless the heliometer gave the most accurate results. The heliometer is a telescope whose object-glass is cut in half, and each half can be delicately moved with reference to the other, forming two images of the same star, or two stars whose distance apart is to be measured can be made to coincide and the distance read off. The telescope tube can be rotated in its bearings, or even object-glass and eye-end interchanged, and from the manner of using the instrument many of the instrumental errors of the ordinary micrometer can be thus balanced and made harmless. The heliometer is not a common instrument; there is one in America, that at Yale College Observatory, with which considerable work of value in this field has been done. While these visual methods have done very valuable service, photography to-day is much the most promising of the older methods.

If two photographs are taken of the same region six months apart, the shift of the star under discussion can be determined with a measuring microscope. The same minute precautions must be taken, for the quantities to be measured are only a few hundred thousandths of an inch. If desired the photo-

graphs can be made on the same plate, side by side. This is the basis of Kapteyn's method, which promises well for searching out the larger parallaxes from a large number of stars. In this method a plate is taken of a region of the sky containing four or five separate images of all the stars in the region which can be reached with an exposure of moderate length. The undeveloped plate, shielded from light, is then stored away for six months, when a new set of five images close to the former five is secured, and the process repeated again six months later. Then the plate is developed and measured, and the parallax of the stars secured with reference to the parallax of all the stars on the plate. As there are many chances for deterioration on the plate, however, most parallax workers prefer to take the exposures on different plates, instead of on the same plate. In this photographic method the longer the focal length of the telescope employed the larger will be the scale of the plate, and the greater the resulting accuracy of the measures. Accordingly, the most accurate photographic parallaxes are secured to-day with instruments of great focal length. A program of great value has been recently carried through by Dr. Schlesinger with the great Yerkes telescope; the results indicate a higher degree of accuracy than has been hitherto attained, and afford us the best values attainable by present methods in determining the distances of individual stars.

What are the results of the efforts which have been made to solve this exceedingly difficult astronomical problem? The distances of only about three hundred and fifty stars have been separately determined, and those distances which can be assumed as fairly accurately known are doubtless less than two hundred—surely a very small proportion of even the naked-eye stars. As to the accuracy of the results, they are perhaps more disappointing to the layman than to the astronomer, who realizes the difficulty of the problem.

To be Continued.

AN INEXPENSIVE BUT VALUABLE DEVICE FOR THE AMATEUR IN STAR-OBSERVATION.

TILTON C. H. BOUTON.

At the beginning of his work upon variable stars, the writer found difficulty in examining the charts. It was inconvenient to hold a chart and lantern or flashlight while working at the telescope; it was more so to leave the instrument to consult

a chart, and, whatever kind of light might be used when referring to a chart, if bright enough to show well the stars and figures upon it, its dazzling effect was sufficient to render the eye, for two or three minutes after returning to the telescope, insensitive to the faintest stars. The thought occurred that these difficulties might be remedied by making a box lantern, with an opening in front, over which to place a chart having the positions of the stars marked upon it by small perforations. The light would shine through these needle holes in the chart, perfectly and constantly indicating the positions of the stars, and not perceptibly affecting the sensitiveness of the eye. A little experimenting showed the great value of this arrangement, and, so far as known, everyone to whom notice of the device has been communicated, and who has given it trial, is highly pleased with the results.

Dr. Edward Gray, of Eldridge, Cal., informs the writer that the idea is not new; but that it was suggested some years ago by Dr. J. F. Clark, and that there has been upon the market an astral lantern involving that idea. As the writer has adapted his device for aid in variable star observation, and since it is especially suitable for that work, Dr. Gray has twice requested him to describe it in POPULAR ASTRONOMY, that all may have the opportunity to profit thereby. To this request I gladly comply. Dr. Gray has been experimenting, and making improvements in the construction of the disks, especially as to the application of color to them; and he kindly promises to supplement this article by one from his own pen. The device as worked out by the writer is constructed as follows. Make a light wooden box, a foot square at top and bottom, and 13 or 14 inches high. In the side which is chosen for the front, cut out a circular opening 8 inches in diameter, and cover this on the inside of the box with window glass. Make for the opposite side of the box a door, swinging on small hinges; and to this fasten a small, tin, kerosene lamp, (which can be procured at a ten cent counter), so that the flame will be, when the door is closed, directly back of the center of the circular opening.

At the top of the box, directly over the lamp chimney, bore for ventillation a dozen ⅜-inch holes, and the same number also close to the bottom of the door. The wood above the lamp will need to be protected by a piece of tin, so bent as not to close up the holes and prevent draft. Cut a sheet of heavy cardboard, the size of the box, and in this make an 8-inch opening to correspond with the aperture in the box. Hinge this cardboard cover

at the top of the box so as to swing up from the bottom. When the perforated chart is placed between the box and the cover, and the latter is fastened at the bottom by a sliding button, it is held securely in position. Charts can be instantly changed.

Whether to make the charts from thin card board, or from heavy drawing paper which permits more light to shine through, the writer has not fully determined. At present he favors the drawing paper, as it allows so much light to shine through as to distinctly show the lines upon the chart, and renders perfectly legible every letter and figure which is marked in ink. The chart should be nine inches in diameter, if aperture of lantern is 8 inches. This punctured chart may be outlined in any way preferred by the maker, provided he gets his perforations rightly placed upon it. The simplest way for those who are using the Harvard Observatory 8″x10″ charts, is to hold an H. O. chart firmly upon the disk of drawing paper or cardboard, and then with a fine needle punch through both the H. O. chart and the disk at every point where a star is plotted on the chart. Thus the punctured disk will perfectly correspond with the chart, and the chart is not injured by the little needle holes. To finish the disk, mark with ink, at the needle holes, the positions and sizes of the stars, so that they will appear as near in size as possible to the corresponding markings on the H.O. chart, writing plainly the letters and magnitudes of the comparison stars. Then select needles of different diameter for enlarging the hole made by the little needle, using, of course, the largest needle for the largest magnitude to be represented, the next in size for the magnitude below, and so on down to the smallest needle for the faintest star. In this way the full magnitudes are represented as correctly by the perforations as they are by the dots on the H. O. charts. Finish the chart by shaving off, with a very sharp knife or old razor, the projecting burs around the edges of the perforations. In use, so adjust the chart in the lantern that it will show the stars as they appear at the time in the field of the telescope. The lantern should be placed, a little in front and to the left, about three feet from the observer, and at the height of his eye at the time of observation.

So great is the advantage in having the star positions indicated by points of light constantly in sight, and in being able to see upon the perforated chart the letters and figures without the eye being dazzled, that one who has once used this device will never be satisfied to return to former methods.

Hudson, N. H., May 3, 1912.

ASTRAL DISKS AND COLORED STARS.

DR. EDWARD GRAY.

The astral lantern appears to have been independently invented, in different years, by at least two Americans: the Rev. James Freeman Clarke and the Rev. Tilton C. H. Bouton, the latter of New Hampshire. In the earlier instance it was applied to the study of an entire constellation; now it has been happily applied to the study of the variable stars. Its peculiar effectiveness is this; that by the use of punctured disks, the size of the punctures indicating the 'magnitude' of each star, it represents the stars to the eye as shining points, just such as they really are and, ipso facto, more truthfully than any map or chart printed in black and white can possibly do. Particularly in the case of an unknown star is such a disk of genuine service to the investigator, because both the variable and the comparison-stars are represented as they appear in the field of the telescope.

This is true teaching. Leaving to Mr. Bouton the description of the astral lantern itself I will say that, for myself I find a diameter of seven inches the most practical size for the disk; and electric lighting by means of a 3½-volt lamp of 1-candle power, run by two cells of dry battery, to furnish illumination superior to any oil.

A large number of variable stars are strongly colored yellow, orange or red. The idea promptly presented itself to my mind that the astral disks afford the opportunity to represent such stars in their colors. Accordingly I have prepared disks in this way, so that U and RV Cygni shall show themselves as red stars; V Coronae and R Cancri as orange or orange red and so on. When such a disk is illuminated it is very easy to pick out the variable.

It facilitates one's learning in a marked manner. As I may apply for a copyright upon the method, I prefer not to set forth the details in this note; but the ingenuity of many will suggest a way to do it.

THE HYADES GROUP OF STARS.

H. C. WILSON.

About forty years ago* Richard A. Proctor constructed a chart, showing the proper motions of the stars for which there were then available sufficient meridian observations to permit fairly accurate determination of the annual motions in right ascension and declination. On this chart were shown many cases where two or more stars, near each other, were apparently moving in a common direction, with approximately the same angular displacement each year. Whether these stars were really moving in parallel paths and at the same rate could not then be determined, for this requires the knowledge of the distances and line of sight movements of the stars, which were then unknown in most cases. With the increase in available data concerning the parallaxes and radial velocities in the last two decades, the study of the real movements of the stars and the problem of "star-streaming" has become very fascinating. The sun's own movement as a star, has long been an established fact and today the direction of its motion may be regarded as determined within 5°, and its velocity probably within 1 kilometer per second. This statement should be qualified by saying that the velocity is relative to the average of the general system of the brighter stars, and if there is any general systematic stream motion among these stars, the adopted velocity of the sun may be entirely erroneous. With this qualification the sun may be said to be moving toward the point on the celestial sphere whose position for 1900 is Right Ascension 270°, Declination north 30°, with a velocity of 20 kilometers per second.

This is sufficiently accurate to enable us to calculate the effect of our own motion (with the sun) upon the apparent motion of a star, as soon as the parallax and radial velocity of the star are known. Unfortunately the number of available parallaxes has not by any means kept pace with the determinations of radial velocity, and the parallaxes which are available are not sufficiently accurate. Very few are known which may

* *Monthly Notices* R.A.S. XXXIII, p. 105.

not be subject to errors as large as 0.″05, which is a large proportion of the whole parallax in the case of most of the bright stars, and is more than its entire amount for most of the fainter stars.

Fortunately, in the case of a stream of stars, the supposition that they are moving in parallel lines makes the problem of calculating their distances determinate without measurement of the parallax, provided the stars are scattered widely enough (and not too widely) to permit their convergent (the vanishing point of their parallel paths) to be determined, and provided that the radial velocity of at least one star in the stream is known. The projections of the parallel paths upon the celestial sphere will be arcs of great circles, which should all intersect at the vanishing point, or convergent. When this point is found the angular distance of each star from it can be computed, and this angle is the measure of the angle in the right angled triangle, the hypothenuse of which represents the star's velocity through space, relative to the sun, and the sides of which are the star's observed radial velocity and its proper motion reduced to kilometers per second.

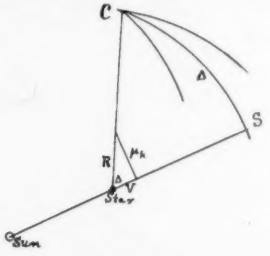


FIGURE 1.

This may be readily seen in Fig. 1, where S is the place of the star on the celestial sphere, as seen from the sun, C is the convergent of the group of parallel moving stars, V is the measured radial velocity, μ_k is the cross velocity, corresponding to the measured annual proper motion, and Δ is the arc CS, measuring the angle at the star. In kilometers per second

$$\mu_k = V \tan \Delta.$$

The velocity of the star through space, relative to the sun, is

$$R = V \sec \Delta.$$

In order to compute the distance ρ of the star we have

$$\rho \tan \mu = s\mu_k,$$
$$\rho = s\mu_k \cot \mu = sV \tan \Delta \cot \mu,$$

where μ is the annual proper motion of the star and s is the the number of seconds in a year. It is better however to use π, the parallax of the star, instead of the distance ρ and, as

$$\rho \tan \pi = \text{radius of earth's orbit} = 149{,}500{,}000 \text{ kilometers},$$

$$\tan \pi = \frac{149{,}500{,}000}{\rho} = \frac{149{,}500{,}000 \tan \mu}{sV \tan \Delta}.$$

Since π and μ are very small we can replace the tangents by the arcs, and substituting for s its value we obtain

$$\pi = \frac{149{,}500{,}000}{365.24 \times 24 \times 60 \times 60} \cdot \frac{\mu}{V \tan \Delta} = \frac{4.74\,\mu}{V \tan \Delta}$$

The determination of the parallax is thus entirely independent of the solar motion, and requires only the knowledge of the star's proper motion, radial velocity, and convergent.

The most remarkable group of stars with a well-determined convergent is that in Taurus, discovered by Professor Lewis Boss* in 1908. The group occupies an area about 18° in diameter, with the familiar V-shaped cluster known as the Hyades near its center. The first magnitude red star Aldebaran does not partake of the common movement, but all the other prominent stars of the Hyades are moving together toward a point about 30° east and 8° south of the star γ, the star at the bottom of the bottom of the *V*. Professor Boss found 41 stars whose proper motions converge to very nearly the same point, within the limits of probable error of the data in most cases. He found the position of the convergent to be for 1875:

R. A. $6^h\ 7^m.2$; Decl. $+ 6°\ 56'$.

With Professor Küstner's values of the radial velocities of the three stars γ, δ and ϵ Tauri, he obtained an average radial velocity for the three of + 39.9 kilometers and, as the average distance of the three stars from the convergent is 28°.9, the relative velocity through space *R*, which on the supposition made must be the same for all the stars of the group, came out 45.6 kilometers. The parallaxes of the three stars came out 0″.025, 0″.025 and 0″.026 respectively. The parallaxes of the remaining 38 stars, on the supposition of equal parallel motion for all, ranged from 0″.021 to 0″.031. Professor Boss did not, in the paper referred to above, give any computation of the real direction of the motion of the group, freed from the effect of the solar motion.

During the past year I have been studying, by a different method, the movements of a hundred of the stars of larger

* *The Astronomical Journal*, XXVI, p. 31

proper motion whose radial velocities have been determined, and to check up my formulae have applied them to the Hyades group. I found upon the record cards at the Lick Observatory good determinations of the radial velocities of 8 of the Hyades stars, which Professor Campbell very kindly allowed me to use. They are given in Table I, together with the values of μ, computed from the data in Boss' Preliminary General Catalogue; ψ the position angle of the proper motion; Δ, from a position for 1900 of the convergent, resulting from my own computations, in R. A. 93° 22′, Decl. + 7° 04′; π and R, calculated by the method described above, after all the other computations had been finished.

TABLE I.

Star	V	μ	ψ	Δ	π	R
	k	″	°	° ′	″	k
γ Tauri	+ 38.0	0.121	102.9	30 23	0.0257	44.0
δ^1 "	+ 38.6	0 116	106.6	30 09	0246	44.6
δ^2 "	+ 38.0	0.124	109.3	29 52	0270	43.8
κ^1 "	+ 41.0	0.112	115.2	31 18	0213	48 0
δ^5 "	+ 36.4	0.110	103.2	29 41	0252	41.9
ϵ "	+ 39.3	0.120	105.1	29 19	0257	45.1
θ^1 "	+ 37.5	0.108	108.4	28 23	0253	42.6
ι "	+ 42.0	0.082	125.0	23 24	0.0214	45.8
Mean	38.8				0.0245	44.5

Professor Boss did not include the star ι Tauri in the group, but it appears to fall in quite perfectly with the others.

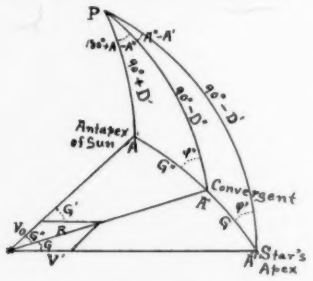


FIGURE 2.

Adopting the average value of $R = 44.5$ kilometers; for the position of the sun's apex of motion the coördinates $A = 270°$ and $D = + 30°$; for the position of the convergent $A'' = 93° 22'$, $D'' = + 7° 04'$; and for the sun's velocity $V\odot = 20$ kilometers, it is possible to calculate the coördinates A' and D' of the point toward which the group is moving, and its velocity V', freed from the effect of the sun's motion, by the following formula:

$$\cos G'' = -\sin D \sin D'' - \cos D \cos D'' \cos (A - A'')$$
$$\sin G'' \cos \phi'' = -\sin D \cos D'' + \cos D \sin D'' \cos (A - A'')$$
$$\sin G'' \sin \phi'' = -\cos D \sin (A - A'')$$
$$k \sin K = \sin D$$
$$k \cos K = \cos D \cos (A - A'')$$

$$\tan K = \tan D \sec (A - A'') \quad (1)$$
$$\tan \phi'' = \tan (A - A'') \cos K \operatorname{cosec} (K - D'') \quad (2)$$
$$\tan G'' = \tan (K - D'') \sec \phi'' \quad (3)$$

$$G'' = G' - G \quad (4)$$
$$V\odot : R :: \sin G : \sin G'$$

$$\frac{R-V\odot}{R+V\odot} = \frac{\tan \tfrac{1}{2}(G'-G)}{\tan \tfrac{1}{2}(G'+G)} = \frac{\tan \tfrac{1}{2} G''}{\tan \tfrac{1}{2}(G'+G)}$$

$$\tan \tfrac{1}{2}(G'+G) = \frac{R+V\odot}{R-V\odot} \tan \tfrac{1}{2} G'' \qquad (5)$$

$$\sin D' = \cos G \sin D'' - \sin G \cos D'' \cos \phi''$$
$$\cos D' \cos(A''-A') = \cos G \cos D'' + \sin G \sin D'' \cos \phi''$$
$$\cos D' \sin(A''-A') = \sin G \sin \phi''$$
$$p \cos P = \cos G$$
$$p \sin P = \sin G \cos \phi''$$

$$\tan P = \tan G \cos \phi'' \qquad (6)$$
$$\tan(A''-A') = \tan \phi'' \sin P \sec(D''-P) \qquad (7)$$
$$\tan D' = \tan(D''-P) \cos(A''-A') \qquad (8)$$

$$V' : R :: \sin G'' : \sin G'$$
$$V' = R \sin G'' \operatorname{cosec} G' \qquad (9)$$

In these formulae G and G' are the angular distances of the star's apex of real motion from the convergent and from the antapex of the sun, respectively; G'' is the distance of the convergent from the solar antapex. The convergent is always between the stars apex and the solar antapex and on the arc of a great circle joining the two. In the computation only the numbered formulæ need be used.

The resulting position for the apex of the Hyades group comes out $A' = 95° 25'$; $D' = +29° 47'$, and the velocity 31.06 kilometers.

By my direct method of finding the apex for each star independently I obtained the results given in the last three columns of Table II. The means of the results when $\pi = 0''.025$ are $A' = 94°.8$; $D' = +30°.7$; $V' = 31.05$ kilometers. In order to use Boss' entire list of 41 stars I adopted for each star a radial velocity 1 kilometer less than that computed by Boss and determined the apices for all the stars. These are plotted in Fig. 3, where lines have been drawn connecting each star with its apex. Inspection of the plot led me to adopt as final values for the coördinates of the apex of the cluster $A' = 95°.5$ and $D' = +29°.5$, but it is evident that there is quite a little margin of uncertainty. A change in the adopted value of the parallax from $0''.025$ shifts the apex along the dotted line AB. It cannot, however, be shifted very far and permit the arc of a great circle to pass through the apex, convergent and solar antapex.

The position of the convergent is shown at C on the plot. The dotted lines extending from the convergent to the group should all be arcs of great circles and hence should be drawn as curved lines No attempt has been made to draw these accurately in the figure.

Similarly the lines drawn from the stars to their apices should be arcs of great circles and, if the stars were actually moving in parallel lines, they should all meet at the same point. The apparent general parallelism of the lines indicate a tendency on the part of many of the stars to diverge, so that the cluster ages hence, if the divergence is real and not merely the result of errors of observation and calculation, may not become so small as Professor Boss suggested, in fact may not become very much smaller than it is now.

TABLE II.

Star	α 1900		δ 1900		Mag.	Type	Assumed π	A'	D'	V'
	h	m	°	′			″	°	°	k
γ Tauri	4	14.1	+15	43	3.8	*G*	0.023	99.8	+28.4	31.7
							025	96.6	+29.5	30.8
							05	72.4	+38.5	28.3
δ Tauri	4	17.2	+17	18	4.0	*K*	0.023	98.3	+28.2	31.5
							025	94.2	+30.0	31.2
							05	71.9	+39.6	28.8
δ^2 Tauri	4	18.3	+17	13	5.0	A_2	0.023	100.1	+24.6	31.3
							025	97.1	+26.6	30.4
							05	74.2	+38.1	28.2
κ^1 Tauri	4	19.4	+22	04	4.5	A_3	0.023	92.2	+28.8	33.8
							025	89.4	+31.4	33.1
							05	69.7	+41.4	32.2
δ^3 Tauri	4	19.7	+17	42	4.4	*A*	0.023	100.4	+32.4	30.1
							025	97.5	+34.3	29.3
							05	73.4	+43.4	27.4
ε Tauri	4	22.7	+18	58	3.6	*K*	0.023	100.0	+28.8	33.0
							025	97.0	+30.1	32.1
							05	74.8	+39.9	30.0
θ^1 Tauri	4	22.9	+15	44	4.0	*K*	0.023	99.5	+29.4	30.0
							025	96.1	+30.9	29.3
							05	73.4	+40.0	27.5
ι Tauri	4	57.1	+21	27	4.7	A_5	0.023	93.9	+30.6	32.2
							025	91.6	+32.6	32.3
							05	78.0	+41.6	32.5
						Mean when $\pi = 0.025$		94.8	+30.7	31.05

Reversing the computation, it is quite easy, given the apex, or direction of motion and the velocity, to calculate the direction and amount of apparent proper motion and the radial velocity, together with the parallax which is consistent with the observed proper motion and the adopted apex. In Table III I have given the results of such a computation for 44 stars, using for the apex $A' = 95°.5$ $D' = +29°.5$ and for the velocity $V' = 31.0$ kilometers. The last star perhaps should not be regarded as a member of this group, for it is of the spectral class B_8 and the computed parallax puts it twice as far away as the average of the group.

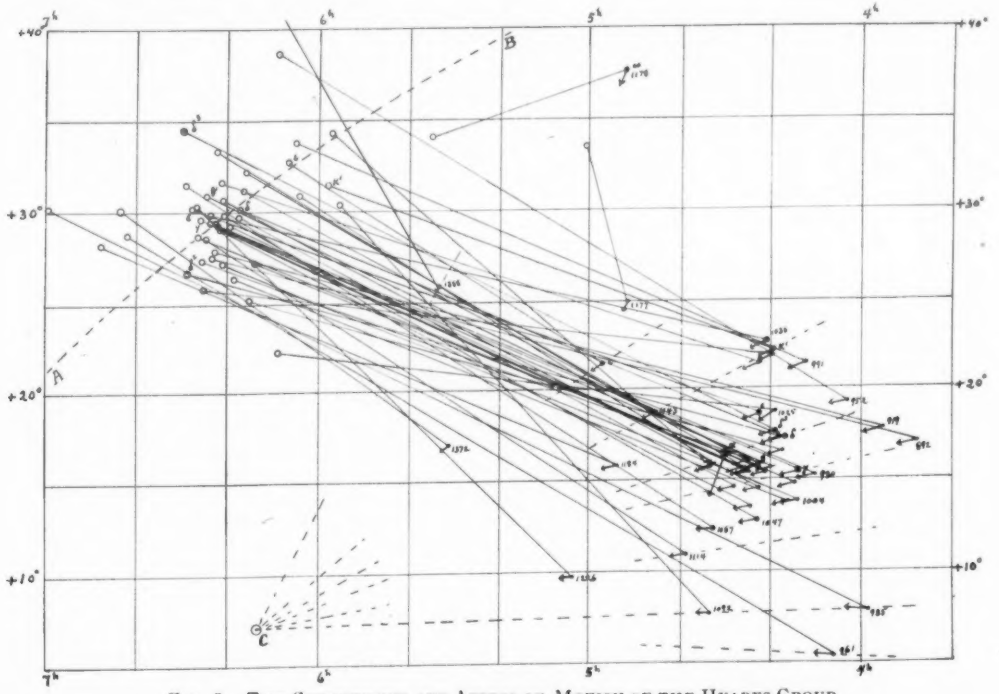


FIG. 3. THE CONVERGENT AND APICES OF MOTION OF THE HYADES GROUP.
The convergent is at C. The Apices of the individual stars are represented by small circles

TABLE III

COMPUTED RADIAL VELOCITIES, PROPER MOTIONS AND PARALLAXES OF THE HYADES CLUSTER.

No. (Boss)	Mag.	Spectral Class	R.A. 1900	Decl. 1900	Calculated V	Calculated μ	Calculated ψ	Residuals (C—O) ΔV	Residuals (C—O) $\Delta\mu$	Residuals (C—O) $\Delta\psi$	Parallax π_1	Parallax π_2
			h m	° ′	k	″	°		″	°	″	″
892	6.3	*F*	3 47.4	+17 02	+35.5	0.147	101.7	...	0.000	— 1.3	0.026	0.025
919	6.2	*F*	55.0	17 55	36.3	142	103 9	...	+ 002	— 1.4	26	25
935	5.7	*A*	3 58.5	7 55	37.1	155	89.7	...	— 004	+ 4.1	28	32
952	5.9	*G*	4 03.3	19 21	38.2	113	108.2	...	— 001	— 3.9	20	29
961	6.0	*F*	06.0	5 16	37.9	144	85.6	...	+ 002	+ 0.9	28	29
980	6.5	*F*	4 10.1	+15 09	+38.1	0.121	102.0	...	—0.003	— 0.4	0.025	0.026
991	5.7	A_5	12.5	21 20	37.4	111	111.4	...	000	+ 0.9	22	22
1000γ	3.8	*G*	14.1	15 23	38.4	119	103.0	+0.4	— 002	+ 0.1	25	26
1004	5.8	*A*	14.3	13 48	38.6	123	100.5	...	+ 002	— 2.9	27	24
1007	5.4	*A*	14.9	14 51	38.5	118	102.6	...	+ 001	— 3.8	27	23
1013	5.9	*A*	4 16.4	+13 50	+38.7	0.121	100.9	...	+0.003	— 4.3	0.028	0.023
1017δ	4.0	*K*	17.2	17 18	38.5	118	107.1	—0.1	+ 002	+ 0.5	24	25
1018	5.9	A_2	17.7	16 33	38.6	112	105.8	...	— 001	— 0.6	25	24
1022δ^2	5.0	A_2	18.3	17 13	38.6	126	106.8	+0.6	+ 002	— 2.5	28	25
1025	6.3	*F*	19.1	18 49	38.5	118	109.8	...	— 005	—11.0	30	20
1026κ^1	4.5	A_3	4 19.4	+22 04	+38.0	0.113	114.5	—3.0	+0.001	— 0.7	0.023	0.022
1027	5.5	A_2	19.5	21 58	38.0	132	114.6	...	+ 001	— 2.6	28	25
1029δ^3	4.4	*A*	19.7	17 42	38.7	112	107.8	+2.3	+ 002	+ 4.5	22	26
1031	6.8	*A*	19.9	15 43	38.9	114	104.2	...	— 002	— 0.3	25	25
1033υ	4.4	A_5	20.3	22 35	38.0	122	115.8	...	— 002	+ 1.0	25	26
1034	4.7	*A*	4 20.6	+15 23	+39.0	0.114	104.0	...	—0.003	+ 0.7	0.025	0.026
1040	6.0	*A*	22.1	21 24	38.3	120	114.6	...	+ 002	+ 2.1	24	26
1043	6.1	A_5	22.7	14 31	39.3	110	102.9	...	+ 000	+ 1.9	24	25
1044ϵ	3.6	*K*	22.7	18 38	38.8	122	110.0	—0.5	+ 002	+ 1.6	25	27
1045θ^1	4.0	*K*	22.9	15 44	39.2	107	105.4	+1.7	— 001	+ 0.3	24	24
1046θ^2	3.5	A_5	4 23.0	+15 39	+39.2	0.108	104 9	...	+0.001	+ 1.4	0.023	0.024
1047	5.2	A_5	23.2	12 50	39.4	109	99.8	...	— 001	+ 0.4	25	25
1051	5.9	*A*	24.4	15 25	39.3	106	105.2	...	— 001	+ 8.7	20	27
1054	4.9	A_5	24.8	15 59	39.3	115	105.6	...	— 001	— 0.4	26	26
1055	5.6	*F*	24.9	15 28	39.4	110	105.0	...	000	— 0.8	25	25
1056	5.6	*A*	4 25.0	+13 30	+39.5	0.113	101.4	...	+0.003	+ 0.9	0.025	0.026
1058	6.3	*F*	26.1	15 38	39.4	109	105.6	...	— 001	— 0.7	25	25
1067ρ	4.8	A_5	28.2	14 38	39.7	104	104 5	...	000	0.0	25	24
1086	6.1	*F*	32.4	15 50	39.9	092	107.2	...	— 001	— 0.8	23	22
1087	4.5	A_5	32.6	12 19	40.3	101	100.5	...	— 004	+ 5.0	23	27
1090σ^2	4 9	*A*	4 33.6	+15 43	40.0	0.083	107.0	...	—0.001	+ 3.3	0.019	0.021
1092	5.6	*A*	33.7	7 40	40.5	083	90.3	...	+ 002	— 0.4	21	21
1114	5.5	*A*	38.9	10 58	40.8	098	97.6	...	000	— 0.6	26	26
1143	5.2	A_5	45.5	18 40	40.5	089	116.2	...	— 001	+ 2.8	22	24
1184	7.0	...	54.0	15 46	41.5	103	112.6	...	— 001	+ 3.4	28	32
1191ι	4.8	A_5	4 57.1	+21 27	40.9	0.083	125.9	—1.1	+0.001	+ 0.9	0.022	0.022
1226	5.7	*A*	5 03.8	9 42	42.5	071	98.6	...	— 003	+ 4.0	23	27
1372	5.8	A_5	31.3	16 59	43.4	068	133.1	...	+ 003	+10.1	28	31
1388	5.2	B_3	5 33.5	+25 50	41.7	0.041	140.9	...	— 003	+ 5.9	0.011	0.015

The two values of the parallax π_1 and π_2 were determined from two components of the proper motion, the one directed toward the solar apex, the other at right angles to that direction. The latter is independent of the sun's motion while the former is not. The close agreement between the two in all cases is therefore very satisfactory.

The residuals in radial velocity, for the eight stars for which that quantity is determined, are quite within the limits of possible error of measurement, the two large ones belonging to stars of the spectral class *A*, in which the lines are not as suitable for measurement as in classes *G* and *K*.

The residuals in position angle ψ of proper motion, agree well, considering the change of the adopted convergent, with those obtained by Professor Boss. The parallaxes also are almost exactly the same as those which he found.

Excluding the last star, the range of the parallaxes is from 0″.020 to 0″.030, i.e., supposing the differences in parallax to be real, the nearest star of the group is two thirds as far away as the farthest, and it is half as far through the group radially as it is from the sun to the nearest star of the group. The center of the group is 30 times as far away from us as is α Centauri, so far that it takes light 131 years to travel from there to us, while it takes 54 years for light to travel from one side to the other of the cluster itself.

This gives us some idea of the vastness of the Hyades group, so enormous as to stagger our imagination, and yet it seems impossible to doubt that within this stupendous reach of space a large number of stars have been subject to a common impulse and are traveling at the same rate in almost parallel paths.

It is interesting to note that in this stream or cluster are stars of the four spectral classes *A*, *F*, *G* and *K*, but none of the classes *B* and *M*.

There is another well-known group of stars in Ursa Major, and perhaps more widely scattered, which possesses very similar movement to that of the Hyades, but directed toward an almost opposite part of the heavens. Of this I expect to write in a later paper.

LAPLACE: EXPOSITION DU SYSTÈME DU MONDE
(Livre 2, Chap. IX)
ATMOSPHERES OF CELESTIAL OBJECTS.

So much has been written recently concerning the Nebular Hypothesis of Laplace, that we have thought that it would be interesting to place before our readers just what Laplace himself said in enunciating the hypothesis. At our request Miss Florence L. Baldwin of the Yerkes Observatory has translated the brief portion of Laplace's Système du Monde which refers to the subject. This is the first statement (published in 1796) by Laplace of his theory, which he develops later in the volume of the Mécanique Céleste devoted to the theory of probabilities. [*Editor.*]

A rare, transparent, compressible and elastic fluid which surrounds an object is called its *atmosphere*. We conceive that each celestial object has such an atmosphere, the probable existence of which for all is indicated by the observations relative to the sun and Jupiter. In proportion as the atmospheric fluid rises above the object it becomes more rare by reason of its elasticity, which expands it by as much more as it is less compressed; but if the outer parts near its surface were elastic, it would expand indefinitely and would end by dissipating itself in space: it is accordingly necessary that the elasticity of the fluid diminish in a greater degree than the weight which compresses it, and that there exist a state of rarity in which this fluid would be without elasticitiy. The atmosphere must be in this state at its surface.

All the atmospheric strata should with time partake of the same motion of rotation as the body which they surround, because the friction of these strata one against the other and against the surface of the body should accelerate the slowest motions and retard the most rapid, until there should be among them a perfect equality. In these changes, and generally in all those which the atmosphere undergoes, the sum of the products of the molecules of the body and of its atmosphere, multiplied respectively by the areas which their radii vectores projected on the plane of the equator describe around their common center of gravity, remains always the same in equal time. Assuming then that by some cause or other the atmosphere should happen to contract, or a portion should condense at the surface of the body, the motion of rotation of the body and of the atmosphere will thereby be accelerated; for, the radii

vectores of the areas described by the molecules of the original atmosphere becoming shorter, the sum of the products of all the molecules by the corresponding areas cannot remain the same unless the speed of rotation increases.

At the surface of the atmosphere, the fluid is held only by gravity, and the figure of the surface is such that the resultant of the centrifugal force and gravity is perpendicular to it. The atmosphere is flattened toward its poles, and distended at the equator; but this flattening has limits, and in the maximum case the ratio of the polar to the equatorial axis is as 2 to 3.

At the equator the atmosphere can extend only as far as the point where the centrifugal force exactly balances gravity, because it is clear that beyond that limit the fluid must be dissipated. With regard to the sun, this point is at a distance from its center equal to the radius of the orbit of a planet which would make its revolution in a time equal to that of the rotation of the sun. The solar atmosphere does not extend then to the orbit of Mercury, and consequently it does not produce the zodiacal light which appears to extend even beyond the earth's orbit. Moreover, this atmosphere, the polar axis of which should be at least 2/3 of that of its equator, is far from having the lenticular form which observations give to the zodiacal light.

The point where the centrifugal force balances gravity is as much nearer the body as the motion of rotation is more rapid. Assuming that the atmosphere extends to this limiting point, and that afterwards it contracts and condenses by cooling at the surface of the body, the motion of rotation will become more and more rapid, and the limit of the atmosphere will approach indefinitely near its center. The atmosphere will throw off then successively, in the plane of its equator, fluid zones which will continue to revolve around the body, since their centrifugal force is equal to their weight; but this equality not existing relative to the molecules of the atmosphere remote from the equator, they will not cease to belong to it. It is probable that the rings of Saturn are zones thus thrown off by its atmosphere.

If other bodies revolve around the one we are considering, or if it revolves around another body, the limit of its atmosphere is the point where its centrifugal force plus the attraction of the other body balances exactly its gravity. Thus the limit of the atmosphere of the moon is the point where the centrifugal

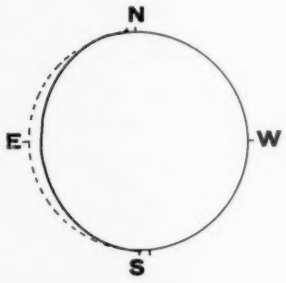
force due to its motion of rotation, plus the attraction of the earth, is in equilibrium with the attraction of this satellite. The mass of the moon being, as we have already seen, 1/58.7 that of the earth, this point is distant from the center of the moon by about 1/9 of the distance from the moon to the earth. If at this distance the original atmosphere of the moon has not been deprived of its elasticity it will move toward the earth, which could thus draw it in; this is perhaps the reason why that atmosphere is so little evident.

THE OCCULTATION OF ANTARES, JUNE 26, 1912, AS VISIBLE IN THE UNITED STATES.

WILLIAM F. RIGGE, S. J.

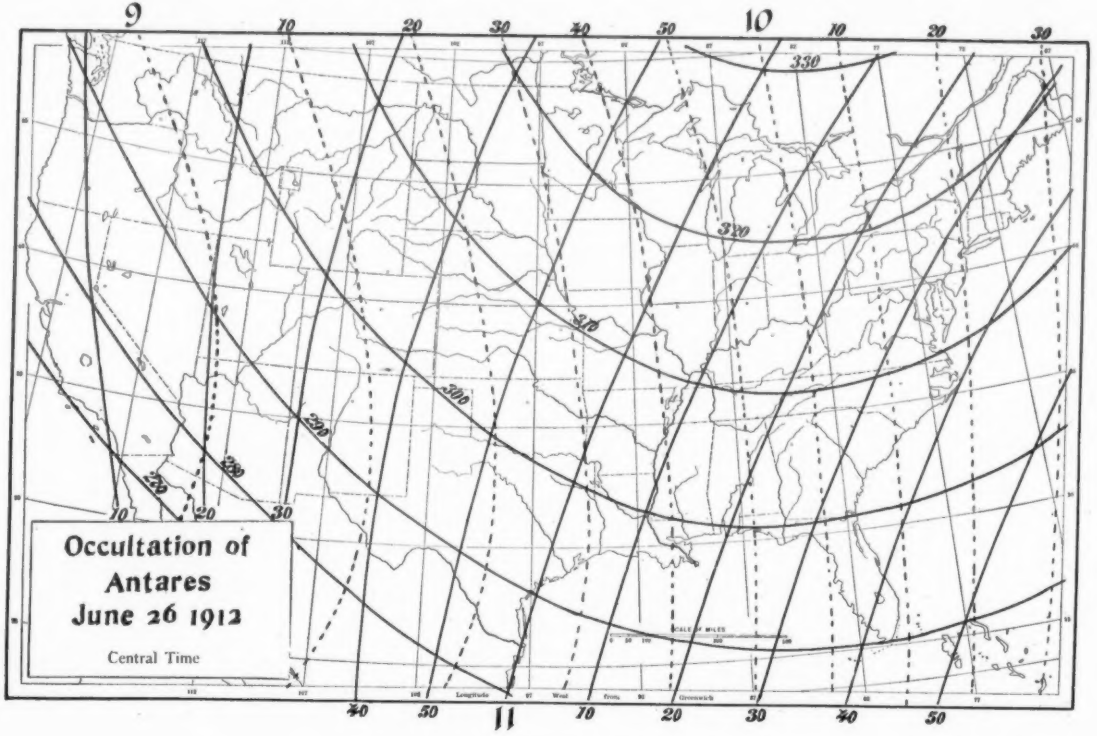
The occultation of Antares on June 26, 1912, will be completely visible all over the United States, although the great southern declination of the star will place it rather low in the sky.

On the annexed map the broken lines give the central times of immersion for every ten minutes from 9:00 to 10:30 P. M. The full lines give in like manner the times of emersion from 10:10 to 11:50. The third set of curves, numbered from 270 to 330, shows the position angles at emersion, measured in the usual way from the north point towards the east.



The moon will be nearly full on the night of the occultation. The star will disappear at the dark limb at some point between east and north. It will reappear at the bright limb between the west point and 30 degrees of the north point, that is, between the position angles 270 and 330 as indicated on the map. It may be of service to know that the north point of the moon's disk will be 4° 43′ to the right of the upper end of the terminator. This will enable those that do not have an equatorial mounting and do not know the parallactic angle, to estimate the position angle of the star from the end of the terminator.

Creighton University Observatory.
Omaha, Nebr.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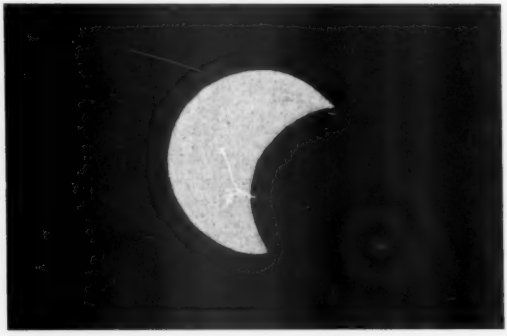
290
280
270
Occultation of
Antares
June 26 1912
Central Time

THE ECLIPSE OF APRIL 17, 1912 AS VISIBLE IN FRANCE.

B. G. HARRISON.

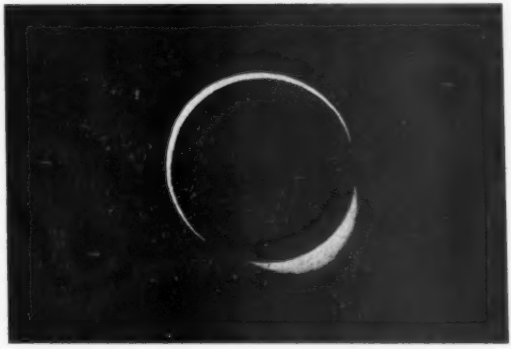
A view of the recent solar eclipse from any station in France lying on the central line traced by the moon's shadow promised to prove of considerable interest; for these points afforded the most favorable positions of witnessing whether it were possible to see any of the phenomena associated with totality in an eclipse that was, strictly speaking, only annular. This consideration decided the writer to go to St. Germain-en-Laye, the position of which, situated on a plateau overlooking the Seine, offered an admirable vantage ground.



At 11:30 A.M.

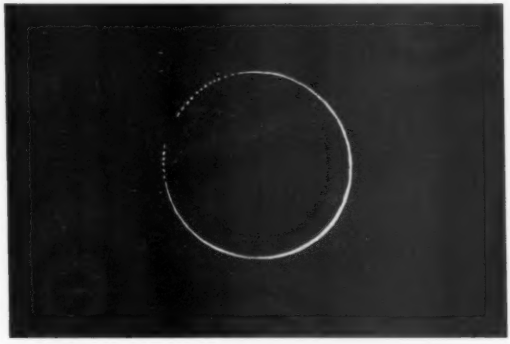
The usual spectacle of the approaching event had induced a large number of Parisians to make the twelve mile journey which separates this spot from the capital, and before 10:15 a. m. an animated crowd, numbering some thousands, had assembled. By this time the brilliant sunshine of the early morning was partially veiled by a thin haze, causing the many astronomers amongst the spectators some anxiety lest the conditions for careful observation were not to be so perfect as they had promised at daybreak. Fortunately almost at the commencement of the eclipse (10:49 A.M.) the atmosphere began to clear again and for twenty minutes after first contact the sunlight actually increased in intensity instead of decreasing! By 11:30 A. M., however, it had become noticeably darker, and as more and more of the Sun's disk was obscured, the usual effects

of light and shade were observable, producing an uncanny feeling of impending disaster. The weirdness of the hour was enhanced by the appearance of some dozen balloons which had risen from different parts of the surrounding country and which now hung apparently motionless like spectres in the darkening sky.



At $12^h\ 9^m\ 42^s$.

About six seconds before complete annularity the writer noticed that some 80° of the following lunar limb was outlined by a band of light, showing bright against the moon's edge, but fading rapidly in the opposite direction, the maximum width



At $12^h\ 9^m\ 50^s$

visible being probably between 3′ and 5′. A direct comparison between its bright edge, and a thread of the photosphere on the opposite side showed that the former was very much fainter,

too faint indeed to justify the inference that this was actually a part of the photosphere reappearing and that its diffused appearance was an optical delusion caused by irradiation. There can be little doubt, therefore, that this was a portion of the corona itself that the moon rendered visible for one brief instant.

Almost before one had time to realize it this phase had disappeared, and attention was centered on the opposite limb. As our satellite reached this point the excitement of the crowd grew intense, and when at $12^h\ 9^m\ 48^s$ the entire lunar disk was momentarily seen silhouetted against its brilliant background a spontaneous cry arose followed by an enthusiastic clapping of hands. So little sunlight was left at this instant that it was possible to observe the eclipse with the naked eye without straining one's eyesight in the least. Venus was easily visible about 22° to the southwest, while Mercury, although close to the sun, is also said to have been noticed.*

The difference in the apparent diameters of the sun and moon was so infinitesimal that annularity seemed to have no sooner commenced than it had passed, and one was only able to obtain a fleeting impression of the circlet of light moving with extreme rapidity from the preceding to the following edge of our satellite. This luminous ring was broken up by the encroachment of the lunar mountains, which rendered the well-known phenomenon of Baily's beads distinctly visible and provided the most vivid moment of the whole eclipse. The word "beads" gives no idea of their extraordinary radiance, and it is difficult for anyone who has not actually seen them to realize their wonderful beauty. It seemed indeed as if it were the crowning tribute of Helios to Selene, in placing upon her brow a diadem of exquisite diamonds. The occultation of a bright star is always an interesting sight, even though its proximity to the moon causes it to lose much of its brightness before it is actually obscured; here, however, was a crescent containing several points of light infinitely more brilliant than any star, which were occulted almost simultaneously.

There was no apparent indication of a coronal band on the eastern side, and with the disappearance of the beads one felt that the fascination of the eclipse, at all events for naked eye observers, was practically at an end. Slowly the western limb

*I did not see either of these planets myself, as my entire attention at this time was given to observing the sun. B.G.H.

of the sun reappeared and by 1:32 p. m. the whole disk was again visible. Thus ended the spectacle which, in its close approach to totality, combined with the perfect conditions for observation, evoked an interest that has probably been unsurpassed in the whole history of annular eclipses.

ROYAL SOCIETIES CLUB LONDON,
April 1912.

OPTICALLY ASSOCIATED STARS.

M. B. THOMAS.

Every observer has noticed the irregularity of star distribution. Now if the stars were placed regularly and evenly as to magnitude as well as number, taking the area of the whole heavens as 41,253 square degrees, then:

20 first magnitude stars	would be about	45°	apart
80 first and second "	" " "	23½°	"
250 down to and including third mag.	"	13°	"
750 " " " " fourth	" "	7½°	"
7000 stars visible to naked eye	"	2½°	"

How different from this is the optical association of the stars and the tendency to richness or barrenness, to groups, clusters and double stars. It is well to note, what has previously been pointed out, the tendency to richness in the immediate vicinity of the Milky Way, and among rich regions we might place that portion including the following part of Argo, the Southern Cross and the southern portion of Centaurus. This is particularly rich in first and second magnitude stars. Another rich region mentioned by the late Mr. Gore has α Lupi for its center, but contains few stars above the third magnitude. The area including Scorpio and Sagittarius is also particularly favored with bright stars and the same may be said of Canis Major, Taurus, Orion and Gemini. The southern constellation Grus, although of small size, contains two second magnitude stars and several brighter than the fourth, arranged in a beautiful stream or curve. Of barren regions it might be mentioned that the area immediately surrounding the south pole, down to 70° south, contains only one star brighter than the third magnitude, β Hydri mag. 2.9. The star γ Hydri is however rated 3.1, but all others are much below this. Another barren region in bright stars is

that near Cor Hydrae; so much is this the case that this star seems to be much brighter than it is, owing to want of contrast. We are apt to think that the stars are much more crowded than they are. Thus, for example, it has been remarked that a count of the stars within the great square of Pegasus will show but few stars. By the way this is by no means a perfect square; a rough estimation shows that from α to γ Pegasi is about 14½°; while from β Pegasi to α Andromedae is less than 12°. These four stars are nearly the average distance apart for stars down to third magnitude.

When we get bright stars separated by a small angle we naturally associate them, and the constellation or part of a constellation they form is rendered all the more conspicuous. Hence the beauty of the southern Cross and the two pointers, the angular distances of which for such bright stars are unsurpassed in the whole heavens:

α *Crucis* (mag. 1.0)	to β Crucis (mag. 1.5)	less than 4°
β Crucis (mag. 1.5)	to γ Crucis (mag. 1.6)	about 3°
γ Crucis (mag. 1.6)	to δ Crucis (mag. 3.1)	about 2¼°
δ Crucis (mag. 3.1)	to α *Crucis* (mag. 1.0)	about 4½°
α *Centauri* (mag.—0.1)	to β *Centauri* (mag. 0.8)	about 3°
β *Centauri*	to β *Crucis*	about 4½°
β *Centauri*	to α *Crucis*	about 7°

Thus the three first magnitude stars (*italicised*) are closer together than the average of stars down to the fourth magnitude. Of second magnitude stars we have the well-known Orion constellation, and more particularly the belt; the distance between the middle star and each of the outer ones is a little over 1⅓°. α and β Gruis, magnitudes 1.9 and 2.1 respectively, are I find about 4° apart, a little closer than α and β Geminorum (1.3 and 1.6 magnitudes) which are about 4¼°. The stars in the head of the eagle, α Aquilae (mag. 0.9) and β Aquilae (mag. 3.9) are 2½° and more apart, while α and γ Aquilae (mag. 2.8) are a trifle over 2° apart. The stars in Canis Major known as ε (mag. 1.6), 22 or 6 (mag. 3.0) and δ (mag. 2.0) are also close together. ε is a little over a degree from the very red star 22, while δ is less than two degrees from the same star. The two stars o^1 Canis Majoris (mag. 4.0) and o^2 Canis Majoris (mag. 3.0) are somewhat over a degree and a half apart. The stars δ Ophiuchi (mag. 3.0) and ε Ophiuchi (mag. 3.3) are less than a degree and a half apart.

Other examples of bright stars close together will be seen in Corvus, Corona Borealis, Sagitta, Delphinus, etc., etc.

Sometimes bright stars closer than one degree of arc seem

to be associated as pairs; familiar examples of these are β and γ Arae (2.7 and 3.5, sep. 51′); μ and ν Centauri (3.3 and 3.5, sep. 47′); o and ξ Tauri (3.8 and 3.8, sep. 44′), etc.; while κ Centauri (3.3) and β Lupi (2.7), υ^3 and υ^4 Eridani (4.0 and 3.8), o^1 and o^2 Eridani (4.1 and 4.5), α and β Muscae (2.9 and 3.4), γ and τ Centauri (2.4 and 5) are about 1° apart.

We can further remark λ and υ Scorpionis (1.8 and 2.8), two very bright stars only 35′ apart; δ and η Corvi (3.1 and 4.4) only 30′.5; and ψ^1 and ψ^2 Aquarii (4.5 and 4.6) are separated by 28′. ψ^3 Aquarii, of about the fifth magnitude, is about the same distance from ψ^2.

I have made out a list of naked-eye doubles visible here, including only those in which one of the components is brighter than 4½ magnitude. Examination of these with binocular or low power will well repay anyone. In many cases I believe the association is only optical, while in others the two stars have similar proper motions. A good instance of this is furnished by a pair of small sixth magnitude stars, ζ^1 and ζ^2 Reticuli; the distance between the two is less than 7′ and in each case the proper motion is large, over 1″. I do not know if any parallax has been found for this couple.

	h	m	″	°	′	″
ζ^1 Reticuli (6.2)	3	15.6	(+ 0.195)	−62	58	(+ 0.65)
ζ^2 Reticuli (5.8)	3	16.0	(+ 0.192)	−62	53	(+ 0.66)

The following list might I believe be extended:

	Magnitudes	
δ and 77 Aquarii	3½, 5	
b^1b^2 Carinae	4½, 4½	
ξ Puppis	3.4, 5	
π Puppis	2.8, 5	Low power resolves into a group.
θ Carinae	3.0, 5	Low power shows a cluster.
o Velorum	4, 4	Principal stars; and pretty triangular group.
$\alpha^1\alpha^2$ Capricorni	4.5, 3 8	Separation 373″.
γ Centauri	2.4, 4½	
δ Centauri	2.8, 5	Three stars with low power.
ζ and χ Ceti	3.9, 5	
δ^1 δ^2 Circini	4, 4	
β Circini	4, 6	
53 Eridani	4, 6	
ξ^1 Geminorum	3.4, 4½	
ι and 59 Geminorum	3.8, 5.7	
δ^1 δ^2 Gruis	4, 4½	
ζ Leonis	3½, 5	
α Librae	2.9, 5.4	Sep. 230″; proper motions similar.
β Lupi	2.7, 6	
τ^1 τ^2 Lupi	4½, 4½	
ϵ Lyrae	4.8, 4.4	Sep. 207″; the famous double-double.

	Magnitudes.	
γ^1 γ^2 Normae	4½, 4	
ι Orionis	3.0, 5	Sep. about 8′; both ι Orionis and the 5th mag. star are again double.
α and β Sagittae	4½, 4½	
β^1 β^2 Sagittarii	3.7, 4.0	
ω^1 ω^2 Scorpionis	4.3, 4.6	Sep. about 13½′.
μ^1 μ^2 Scorpionis	3.6, 4.0	Separation 265″.
ξ^1 ξ^2 Scorpionis	4, 5	
ι^1 ι^2 Scorpionis	3, 5	
μ and 36 Serpentis	3½, 5	
Pleione and Atlas	4.0, 6.2	In the Pleiades; sep. about 5′.
θ^1 θ^2 Tauri	4, 4	Sep. 337″; similar proper motions.
δ^1 δ^2 Tauri	5, 4	
κ^1 κ^2 Tauri	4, 5½	Sep. 339″.
υ^1 υ^2 Tauri		
β Toucani	4, 5	
λ and μ Muscae	4, 5	

Some of these naked eye doubles are exceedingly beautiful. I may specially mention that in the southern constellation Grus δ^1 and δ^2, one of the components is very red the other white. Those in Scorpio, Taurus, Capricornus, Orion and ξ Argus (Puppis) (a red primary and white small star) are very beautiful objects. The eye seems to easily separate the stars when the interval is not less than 5′. When the stars are closer, and the magnitudes differ, prolonged gaze is necessary. How much is the actual distance which separate these apparently associated stars? Where the magnitudes are the same we might, perhaps erroneously, infer that the distance from us was the same for both stars, but only an estimation of the parallax of each would enable us to tell what distance apart they really were.

However, assume the case of two fourth magnitude stars 5′.5 (330″) apart, such as θ^1 θ^2 Tauri, with a parallax of 0″.015; we should have then 13,750,000 times the suns distance from us and not less than 22,000 times the same distance apart. If we take a parallax ten times as large, the distance that separates them will still be very great, while if we take a smaller parallax of course their distance from each other will be correspondingly increased.

Glenorchy, Tasmania.

OBSERVATIONS OF NOVA (2) GEMINORUM.

FREDERICK C. LEONARD.

The following observations* of Enebo's Nova (2) Geminorum have been made since my article on the above subject in the May issue of POPULAR ASTRONOMY was completed. Telescope used, 3-inch equatorial refractor; power, 28 diam., field about 1° in aperture.

OBSERVATIONS OF NOVA (2) GEMINORUM

1912 April 11—May 13.

C.S.T. of 1912	Obs'n. h m	Mag.	Comparison stars.	Color.
April 11	7 40	6.7	BD. + 32° 1414 and 1433	Decidedly deep red.
14	7 30	6.9	BD. + 32° 1414 and 1433	Very light red.
15	7 50	7.0	BD. + 32° 1414 and 1433	Decidedly red.
18	8 0	6.9	BD. + 32° 1414, 1433 and 1437	Pink.
20	7 55	7.0	BD. + 32° 1414, 1433 and 1437	Very light red.
21	7 50	7.0	BD. + 32° 1433 and 1437	Very light red.
22	8 20	6.8	BD. + 32° 1414, 1433 and 1437	Strongly red.
23	7 50	6.8	BD. + 32° 1414, 1433 and 1437	Decidedly red.
24	8 5	6.9	BD. + 32° 1433 and 1437	Fiery red.
26	7 55	7.1	BD. + 32° 1433 and 1437	Rather decidedly red.
27	8 0	7.0	BD. + 32° 1433 and 1437	Rather light red.
29	7 55	7.1	BD. + 32° 1433 and 1437	Rather decidedly red.
30	8 40	6.8	BD. + 32° 1414, 1433 and 1437	Pink.
May 1	8 10	6.9	BD. + 32° 1414, 1433 and 1437	Rather decidedly red.
4	8 0	7.2	BD. + 32° 1433 and 1437	Very red.
5	7 50	7.2	BD. + 32° 1433 and 1437	Red.
7	7 50	7.2	BD. + 32° 1433 and 1437	Rather light red.
8	8 20	7.4	BD. + 32° 1433 and 1437	Red.
9	8 10	7.5	BD. + 32° 1433 and 1437	Red.
13	8 15	7.6	BD. + 32° 1433 and 1437	Red.

The magnitude and position, (1855.0), of the one additional comparison star, (B D. +32° 1437), made use of it in the above summary of observations, are as follows:

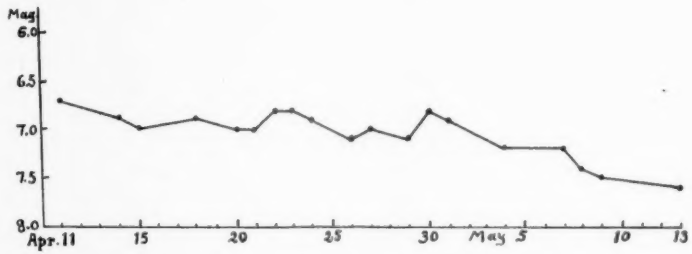
BD. + 32° 1437, mag. 8.0, α 6^h 45^m $27^s.9$ δ + 32° 40′.3

I give below the light curve of the Nova for the period 1912 April 11-May 13, prepared from the magnitudes listed in the foregoing table.

It will be noticed from the light curve of the Nova that, for the most part, its changes in magnitude during the past month have been very irregular, but that they have generally confined themselves to somewhat slight fluctuations above and below the seventh-magnitude line. Since May 7, however, the star seems to be on a slow decline. It will be noted also that the variations in color of the Nova in the course

* Excepting the first which is herein repeated for purpose of reference.

of the period in which the accompanying observations were made have mainly corresponded to its shifts in brightness, as was so clearly brought out by the preceding observations.† For the present set of observations the best instances of this fact that can be taken are those of the highest and the lowest points attained by the Nova during the month, namely those



LIGHT CURVE OF NOVA (2) GEMINORUM, April 11—May 13.

occurring on the dates April 30 and May 3, respectively. We find, upon reference to the above observations, that on the former date the star was pink, while on the latter it was really red. Since the beginning of the present decline, May 7-13 so far, the Nova has very gradually deepened in color as it has decreased in magnitude. The color of the star on a very considerable number of the observations during the month just completed has not, however, by any means been as red as one might naturally be led to expect it would be for its magnitude, (in proportion to what it was in March–April), and certainly not as pronounced in color as it was on several of the observations of the first set.†

In the course of my observations of Nova (2) Geminorum, (1912 March 15 and April 24), I have examined it under high powers, (84 and 126 diam.), but at no time have found its disk in any respect different from that of any ordinary fixed star.

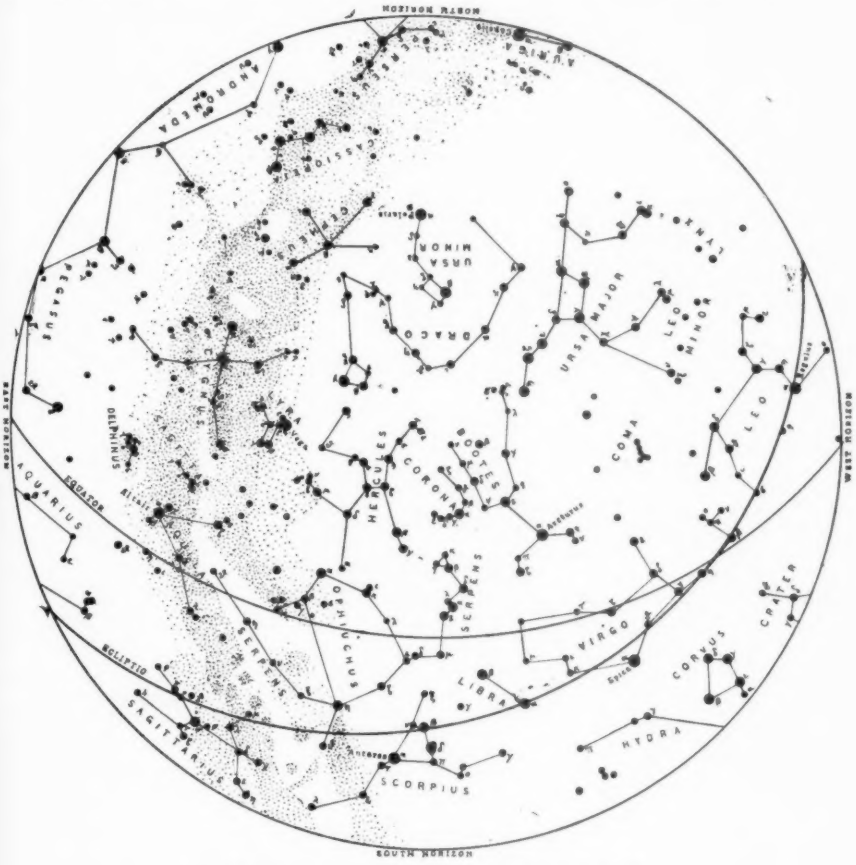
1338 Madison Park, Chicago, Ill.
May 14, 1912.

† See May, 1912, number of POPULAR ASTRONOMY, No. 195 pp. 310-313.

PLANET NOTES FOR JULY AND AUGUST, 1912.

C. H. GINGRICH.

The sun at the beginning of these two months will be near its greatest declination north and will be moving southward. Its diurnal path is that of a spiral which carries the sun a little farther south each day. Its eastward



THE CONSTELLATIONS AT 9:00 P. M. JULY 1, 1912.

motion during this period carries it from the constellation Gemini through Cancer into Leo. At the end of August the sun will be very near the bright star Regulus, which will necessarily be invisible at that time. On July 4 the earth will be at its greatest distance from the sun. It will then be about 3,000,000 miles farther from the sun than on Jan. 1, 1913.

The phases of the moon for these months are as follows;

Last Quarter	July	7	at 11 A. M.	C. S. T.
New Moon		14	" 7 A. M.	"
First Quarter		20	" 11 P. M.	"
Full Moon		28	" 10 P. M.	"
Last Quarter	Aug.	5	at 10 P. M.	C. S. T.
New Moon		12	" 2 P. M.	"
First Quarter		19	" 11 A. M.	"
Full Moon		27	" 2 P. M.	"

Mercury will be invisible at the beginning of this period but will be moving eastward faster than the sun and will reach its greatest distance from the sun eastward on July 24. Near this date it may be seen near the western horizon shortly after sunset at a point several degrees south of the sun. It will then move toward the sun again and will pass the sun a few degrees south of it on August 21.

Venus will be very near the sun at the beginning of July. On July 5 it will pass the sun on the opposite side from the earth. On this date it will be less than a degree from the sun. It will be invisible until the latter part of August when it will again become the evening star. It reaches its point nearest to the sun in miles on July 21.

Mars will move eastward nearly as rapidly as the sun and will be visible near the western horizon at sunset throughout these two months. Mars will be approaching its greatest distance from the earth and consequently it will not be conspicuously bright, being only of about the second magnitude.

Jupiter will be the most conspicuous object in the sky during these months. It will be some distance above the horizon on July 1 at sunset, and will be higher each succeeding day. It will be about as bright as the star Sirius. Throughout the period it will be in the constellation Scorpio, not very far from Antares. At the close of August it will be on the meridian at sunset.

Saturn will be the morning star during this period. On August 29 it will be on the meridian at sunrise.

Uranus will be in opposition with the sun on July 24. At this season it will therefore rise at the time of sunset.

Neptune During the early part of this period will be too near the sun to be visible. It will be in conjunction with the sun on July 15. In the latter part of August it may again be found in the morning sky.

Occultations visible at Washington.

Date 1912		Star's Name	Magnitude.	IMMERSION. Washington M.T. h	m	Angle f'm N. °	EMERSION. Washington M.T. h	m	Angle f'm N °	Duration h	m
July	2	κ Capricorni	4.8	9	54	24	10	40	302	0	46
	9	δ Arietis	4.5	13	09	81	13	59	229	0	50
	16	37 Leonis	5.5	8	53	93	9	38	320	0	45
	18	27 B Virginis	6.5	8	18	203	8	31	226	0	13
	27	ω Sagittarii	4.8	13	51	25	14	50	288	0	59
	27	A Sagittarii	4.9	15	27	74	16	32	240	1	05
Aug.	3	ζ Piscium	5.6	11	50	13	12	38	279	0	48
	4	12 H' Arietis	6.3	12	59	36	14	02	254	1	03
	8	136 Tauri	4.6	13	41	92	14	31	247	0	50
	17	40 H Virginis	5.1	8	19	154	9	11	253	0	52
	19	3 Scorpii	5.9	8	04	149	9	04	241	1	00
	26	29 Aquarii(*mean*)	6.5	8	31	67	9	56	236	1	25

Phenomena of Jupiter's Satellites.

Central Standard Time.

Note.—In.. denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

1912	h	m			
July 1	12	01	I	Tr.	In.
	12	43	I	Sh.	In.
	14	14	I	Tr.	Eg.
	14	56	I	Sh.	Eg.
2	7	56	II	Tr.	Eg.
	9	18	I	Oc.	Dis.
	9	23	II	Sh.	Eg.
	12	11	II	Ec.	Re.
3	6	28	II	Tr.	In.
	7	11	II	Sh.	In.
	8	41	I	Tr.	Eg.
	9	25	I	Sh.	Eg.
5	11	19	III	Tr.	In.
	13	22	III	Tr.	Eg.
9	6	42	III	Ec.	Re.
	7	36	II	Tr.	In.
	9	16	II	Sh.	In.
	10	16	II	Tr.	Eg.
	11	04	I	Oc.	Dis.
	11	57	I	Sh.	Eg.
	14	05	I	Ec.	Re.
10	8	15	I	Tr.	In.
	9	06	I	Sh.	In.
	10	28	I	Tr.	Eg.
	11	20	I	Sh.	Eg.
11	8	34	I	Ec.	Re.
	8	37	III	Ec.	Dis.
	9	56	II	Tr.	In.
	10	42	III	Ec.	Re.
	11	51	II	Sh.	In.
	12	36	II	Tr.	Eg.
	12	51	II	Oc.	Dis.
17	10	03	I	Tr.	In.
	11	02	I	Sh.	In.
	12	17	I	Tr.	Eg.
	13	16	I	Sh.	Eg.
18	7	18	I	Oc.	Dis.
	9	02	II	Ec.	Re.
	10	29	I	Ec.	Re.
19	7	44	I	Sh.	Eg.

	h	m			
July 23	8	16	II	Oc.	Dis.
	10	25	III	Oc.	Re.
25	9	07	I	Oc.	Dis.
	11	40	II	Ec.	Re
26	7	26	I	Sh.	In.
	8	33	I	Tr.	Eg.
	9	40	I	Sh.	Eg.
Aug. 1	9	16	II	Oc.	Dis.
	10	57	I	Oc.	Dis.
2	8	11	I	Tr.	In.
	9	21	I	Sh.	In.
	10	24	I	Tr.	Eg.
	11	35	I	Sh.	Eg.
3	8	40	III	Sh.	Eg.
	8	47	I	Ec.	Re.
	8	59	II	Sh.	Eg.
9	10	03	I	Tr.	In.
	11	16	I	Sh.	In.
10	7	16	I	Oc.	Dis.
	7	36	III	Tr.	Eg.
	8	52	II	Sh.	In.
	9	07	II	Tr.	Eg.
	10	19	III	Sh.	In.
	10	42	I	Ec.	Re.
11	6	45	I	Tr.	Eg.
	7	59	I	Sh.	Eg.
17	8	56	II	Tr.	In.
	9	09	I	Oc.	Dis
	9	12	III	Tr.	In.
18	7	40	I	Sh.	In.
	8	38	I	Tr.	Eg.
	9	55	I	Sh.	Eg.
19	7	05	I	Ec.	Re.
	8	53	II	Ec.	Re.
21	6	44	III	Ec.	Re.
25	8	19	I	Tr.	In.
	9	39	I	Sh.	In.
26	9	00	I	Ec.	Re.
27	6	19	I	Sh.	Eg.
28	8	30	III	Ec.	Dis.

VARIABLE STARS.

Approximate Magnitudes of Variable Stars on May 1, 1912.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R.A. 1900. h	m	Decl. 1900. °	′	Magn.
X Androm.	0	10.8	+46	27	11.9 *i*	W Androm.	2	11.2	+43	50	13.1
T Cassiop.		17.8	+55	14	8.7 *i*	Z Cephei		12.8	+81	13	<12.0
Y Cephei		31.3	+79	48	9.3	RR Persei		21.7	+50	49	<12.0
W Cassiop.		49.0	+58	1	10.1*d*	RR Cephei		29.4	+80	42	<13.0
S Cassiop.	1	12.3	+72	5	11.6*d*	Y Persei	3	20.9	+43	50	8.5
X Cassiop.		49.8	+58	46	<11.0	R Persei		23.7	+35	20	9.5 *i*

Approximate Magnitudes of Variable Stars on May 1, 1912.

Continued.

Name.	R. A. 1900. h m	Decl. 1900 ° ′	Magn.	Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.
S Tauri	4 23.7	+ 9 44	10.0	T Virginis	12 9.5	− 5 29	<11.0
T Camelop.	30.4	+65 57	8.2	R Corvi	14.4	−18 42	11.9
X Camelop.	32.6	+74 56	8.0	SS Virginis	20.1	+ 1 19	8.9*d*
R Orionis	53.6	+ 7 59	10.9*d*	T Can. Ven.	25.2	+32 3	10.2 *i*
R Leporis	55.0	−14 57	6.5	Y Virginis	28.7	+ 3 52	11.7
V Orionis	5 0.8	+ 3 58	9.7 *i*	T Urs. Maj.	31.8	+60 2	8.6*d*
W Aurigae	20.1	+36 49	<13.0	R Virginis	33.4	+ 7 32	12.1
S Orionis	24.1	− 4 46	9.7	RS Urs. Maj.	34.4	+59 2	10.3 *i*
S Camelop.	30.2	+68 45	8.9*d*	S Urs. Maj.	39.6	+61 38	7.9
U Aurigae	35.6	+31 59	10.3*d*	U Virginis	46 0	+ 6 6	7.6
SU Tauri	43.2	+19 2	<12.0	V Virginis	13 22.6	− 2 39	10.1
U Orionis	49.9	+20 10	6.6 *i*	R Hydrae	24.2	−22 46	7.9*d*
Z Tauri	46.7	+15 46	<13.0	S Virginis	27.8	− 6 41	<11.0
V Camelop.	49.4	+74 30	<13.0	RV Urs. Maj.	29.4	+54 31	<11.0
X Gemin.	6 40.7	+30 23	9.5	T Urs.Min.	32.6	+73 56	<10.0
X Aurigae	4.4	+50 15	8.6 *i*	R Can.Ven.	44.6	+40 2	9.3 *i*
V Monoc.	17.7	− 2 9	8.4	U Urs. Min.	14 15.1	+67 15	9.1
U Lyncis	31.8	+59 57	<14.0	V Boötis	25.7	+39 18	8.3*d*
S Lyncis	35.9	+58 0	<13.0	R Camelop.	25.1	+84 17	12.1*d*
RU Monoc.	49.4	− 7 28	<11.0	R Boötis	32.8	+27 10	8.6*d*
W Monoc.	47.5	− 7 2	<11.0	RT Librae	15 0.8	−18 21	<11.0
Y Monoc.	51.3	+11 22	12.5d	Y Librae	6.4	− 5 38	8.9*d*
R Lyncis	53.0	+55 28	11.1*d*	S Cor.Bor.	17.3	+31 44	9.6*d*
V Can. Min.	7 1.5	+ 9 2	<14.0	S Serpentis	17.0	+14 40	9.5
R Gemin.	1.3	+22 52	11.9 *i*	S Urs.Min.	33.4	+78 58	11.9
R Can. Min.	3.2	+10 11	12 0	R Cor. Bor.	44.4	+28 28	7.3
RR Monoc.	12.4	+ 1 17	13.0	X Cor. Bor.	45.2	+36 35	<12.0
S Can. Min.	27.3	+ 8 32	7.3	RZ Scorpii	58.6	−23 50	10.0*d*
T Can. Min.	28.4	+11 58	10.5 *i*	X Herculis	15 59.6	+47 31	6.5
U Can. Min.	35.9	+ 8 37	8.9	Z Scorpii	16 0.1	−21 28	9.1
S Gemin	37.0	+23 41	10.1	U Serpentis	2.5	+10 12	<12.0
RU Puppis	8 3.1	−22 37	9.1 *i*	RU Herculis	6.0	+25 20	<11.0
R Cancri	11.0	+12 2	8.7	W Cor.Bor.	11.8	+38 3	13.2
V Cancri	16.0	+17 36	8.2	U Herculis	21.4	+19 7	10.7*d*
RT Hydrae	24.7	− 5 59	8.7*d*	W Herculis	31.7	+37 32	11.1*d*
U Cancri	30.0	+19 14	<14.0	R Urs. Min.	31.3	+72 28	10.8
X Urs Maj.	33.7	+50 30	9.9 *i*	R Draconis	32.4	+66 58	8.1*d*
S Hydrae	48.4	+ 3 27	8.6 *i*	S Herculis	47.4	+15 7	10.2*d*
T Hydrae	50.8	− 8 46	10.1 *i*	RV Herculis	56.8	+31 22	10.0 *i*
T Cancri	51.0	+20 14	9.0	R Ophiuchi	17 2.0	−15 58	9.4*d*
V Urs.Maj.	9 1.2	+51 31	10.5	V Draconis	56.3	+54 53	<14.0
X Hydrae	30.7	−14 15	12.0*d*	W Draconis	18 5.4	+65 56	12.2
Y Draconis	31.1	+78 18	<14.0	X Draconis	6.8	+66 8	<12.0
R Leo. Min.	39.6	+34 58	10 3*d*	W Lyrae	11.5	+36 38	7.5
RR Hydrae	40.4	−23 34	<12.0	SV Draconis	31.2	+49 18	<13.0
R Leonis	42.2	+11 54	4.7 *i*	X Ophiuchi	33.6	+ 8 44	8.2
— Leonis Min.	42.6	+33 45	10.2	RY Lyrae	41.2	+34 34	<13.0
X Leonis	45.6	−12 21	<12.0	R Scuti	42.2	− 5 49	4.6
V Leonis	54.5	+21 44	12.1*d*	Z Lyrae	56.0	+34 49	12.5 *i*
R Urs. Maj.	10 37.6	+69 18	12.7*d*	V Lyrae	19 5.2	+29 3	<12.7*d*
V Hydrae	46.8	−20 43	9.0*d*	S Lyrae	9.1	+25 50	<13.0
W Leonis	48.4	+14 15	<13.0	UDraconis	9.9	+67 7	12.9*d*
R Crateris	55.6	−17 47	9.0	TZ Cygni	13.4	+5 0	10.8 *i*
S Leonis	11 5.7	+ 6 0	9.7 *i*	U Lyrae	16.6	+37 42	<11.0
X Virginis	56.7	+ 9 38	<10.2	R Cygni	34.1	+49 58	11.7*d*
R Com. Ber.	59.1	+19 20	<13.0	RT Cygni	40.8	+48 32	9.5*d*

Approximate Magnitudes of Variable Stars on Apr. 1, 1912—Con.

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R.A. 1900 h m	Decl. 1900 ° ′	Magn.
X Cygni	19 46.7	+32 40	<11.0	X Cephei	21 3.6	+82 40	<13.0
ZCygni	58.6	+49 46	9.2	T Cephei	8.2	+68 5	8.6 *i*
RS Cygni	20 9.8	+38 28	9.1	S Cephei	36.5	+78 10	8.2
R Delphini	10.1	+ 8 47	8.7	RV Cygni	39.1	+37 34	6.9
U Cygni	16.5	+47 35	7.7*d*	V Cassiop.	23 7.4	+59 8	12.0
ST Cygni	29.9	+54 38	12.3	R Cassiop.	53.3	+50 50	8.1 *i*
T Aquarii	44.7	— 5 31	8.5 *i*	Y Cassiop.	58.2	+55 7	13.0
RZ Cygni	48.5	+46 59	<13.0				

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude. The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:— T. C. H Bouton, E. L. Forsyth, C. E. Furness, Edward Gray, F. E. Hathorn, C. J. Hudson, S. E. Hunter, M. W. Jacobs, Jr., J. B. Lacchini, W. T. Olcott, P. G. O'Reilly, E. R. Padova, E. A. Perkins, P. R. Sutton, H. M. Swartz, H. W. Vrooman, I. E. Woods, A. S. Young.

Minima of Variable Stars of the Algol Type.

[Calculated by Mary H. Wilson at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h, etc.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of minima in **July-Aug.** 1912. d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.6	9 17		22 14	
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	11 5;	23 3;	9 23;	21 21
U Cephei	0 53.4	+81 20	7.1— 9.2	2 11.8	7 21;	22 20;	11 19;	21 18
Z Persei	2 33.7	+41 46	9.4—12.	3 01.4	7 21;	20 2;	7 10;	19 16
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	12 7;	26 0;	8 18;	22 11
RZ Cassiop.	39.9	+69 13	6.4— 7.8	1 04.7	7 18;	19 17;	12 15;	24 14
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	10 15;	21 5;	11 9;	22 0
RX Cephei	2 58.8	+67 11	8.6— 9.1	32 07.6		27 16		28 23
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	8 02;	19 13;	11 12;	22 23
RT Persei	16.7	+46 12	9. —11.	0 20.4	7 22;	18 3;	12 15;	22 19
λ Tauri	55.1	+12 12	3.4— 4.5	3 22.9	9 13;	17 10;	10 4;	18 1
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	8 12;	19 14;	10 17;	22 19
RV Persei	4 04.2	+33 59	10.6—12.8	1 23.4	8 14;	20 11;	7 5;	19 1
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	11 18;	24 22;	7 3;	20 8
RS Cephei	4 48.6	+80 06	9.5—12.2	12 10.1	15 15;	28 1;	9 12;	21 22
RY Aurigæ	5 11.5	+38 13	10.7—11.7	2 17.5	10 23;	21 21;	12 17;	23 15
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	9 21;	21 22;	9 0;	21 1
SV Gemin;	54.6	+24 28	9.8—<11	4 00.2	8 2;	24 3;	9 3;	17 4
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	11 0;	22 11;	8 16;	20 3
U Columbæ	6 11.2	−33 03	9.4—10.2	2 19.2	9 10;	20 15;	12 0;	23 5
56,1908 Gemin.	22.	+20 37	10.8—11.5	1 08.8	10 11;	21 9;	12 6;	23 4
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	10 8;	25 14;	9 20;	17 11
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	9 17;	21 22;	15 8;	27 13
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	8 8;	19 2;	9 15;	20 9
R Canis Maj.	7 14.9	−16 12	5.9— 6.7	1 03.3	8 21;	20 6;	11 23;	23 8
RY Gemin.	7 21.7	+15 52	8.9—<10	9 07.2	12 10;	21 17;	9 7;	18 15
Y Camelop	27.6	+76 17	9.5—12.	3 07.3	8 2;	21 7;	10 3;	23 9
RR Puppis	43.5	−41 08	9.5—	6 10.3	9 16;	22 13;	10 20;	23 17
V Puppis	55.4	−48 58	4. — 5.	1 10.9	11 13;	18 19;	9 15;	24 4

Minima of Variable Stars of the Algol Type.—Continued.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of minima in **July-Aug.** 1912. d h d h d h d h
X Carinæ	8 29.1	−58 53	7.8— 8.9	0 13.0	11 6; 22 2; 12 18; 23 13
S Cancri	8 38.2	+19 24	8. —10.	9 11.6	6 10; 15 21; 13 8; 22 20
S Velorum	9 29.5	−44 46	7.8— 9.5	5 22.4	11 23; 23 20; 10 15; 22 12
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	13 8; 21 18; 7 15; 24 12
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	8 12; 17 18; 14 14; 23 20
SS Carinæ	10 54.2	−61 23	12.2—12.8	3 07.2	9 9; 22 14; 11 9; 24 14
RW Urs. Maj	11 35.4	+52 34	9.3—10.3	7 07.9	11 15; 18 23; 9 22; 17 6
Z Draconis	11 40.6	+72 49	9.5—12.5	1 08.6	7 7; 20 21; 10 6; 17 0
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	13 22; 21 8; 12 16; 20 2
δ Libræ	14 55.6	− 8 07	5. — 6.7	2 07.9	7 17; 21 17; 11 15; 18 15
U Coronæ	15 14.1	+32 01	7.8— 9.0	3 10.9	8 15; 22 10; 12 3; 19 1
TW Draconis	15 32.4	+64 14	7.0— 8.9	2 19.4	12 21; 21 7; 7 3; 23 23
SW Ophiuchi	16 11.1	− 6 44	9.2—10.	2 10.7	10 16; 18 0; 9 0; 23 17
SX Ophiuchi	16 12.6	− 6 25	10.5—11.2	2 01.5	12 1; 18 6; 11 24; 18 5
R Aræ	16 31.1	−56 48	6.7— 8.	4 10.2	8 0; 25 17; 12 10; 21 6
TT Herculis	16 49.9	+17 00	8.9— 9.5	20 18.1	1 6; 22 0; 11 18
TU Herculis	17 09.8	+30 50	9.5—12.	2 06.4	11 11; 18 6; 7 16; 21 6
U Ophiuchi	11.5	+ 1 19	6. — 6.7	0 20.1	12 17; 21 2; 6 21; 23 15
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	7 11; 15 16; 9 5; 17 9
Z Herculis	17 53.6	+15 09	6.7— 8.0	3 23.8	10 13; 18 13; 11 12; 19 11
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	9 5; 19 13; 9 5; 19 13
RS Sagittarii	11.0	−34 08	6.7— 7.8	2 10.0	9 14; 24 2; 7 14; 22 2
V Serpentis	11.1	−15 34	9.5—	3 10.9	12 11; 19 8; 9 2; 22 21
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	7 10; 18 10; 9 11; 20 12
RX Herculis	26.0	+12 32	7.8— 8.0	0 21 3	7 0; 24 19; 11 14; 20 11
SX Sagittarii	18 39.7	−30 36	8.6— 9.4	2 01.8	7 5; 19 16; 7 9; 19 20
RR Draconis	40.8	+62 34	9.3—13.	2 19.9	7 15; 24 15; 10 15; 19 3
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	11 21; 18 22; 7 17; 20 22
U Scuti	18 48.9	−12 44	9.0— 9.8	0 22.9	11 16; 21 5; 9 8; 18 21
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.5	11 6; 20 18; 8 16; 18 4
RV Lyræ	12.5	+32 15	11. —13.	3 14.4	11 12; 18 17; 9 7; 23 17
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	10 12; 19 11; 6 9; 15 8
U Sagittæ	14.4	+19 26	6.7— 9.0	3 09.1	7 12; 21 0; 10 7; 17 1
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	7 7; 22 1; 13 3; 20 12
136.1910 Lyræ	24.3	+41 30	9.0<11.0	5 05.8	7 12; 18 0; 7 23; 18 11
SY Cygni	19 42.7	+32 28	10. —12.	6 00.2	9 23; 21 23; 9 0; 21 0
WW Cygni	20 00.6	+41 18	9.5—12.5	3 07.6	11 16; 18 7; 7 5; 20 11
SW Cygni	03.8	+46 01	9. —12.	4 13.8	13 18; 22 22; 10 5; 19 8
VW Cygni	11.4	+34 12	9.5—11.5	8 10.3	10 9; 18 20; 13 3; 21 13
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	12 5; 19 0; 8 8; 21 22
UW Cygni	19.6	+42 55	10.5—13.	3 10.8	12 23; 19 21; 9 14; 23 9
W Delphini	33.1	+17 56	9.5—11.5	4 19.4	12 14; 22 5; 10 10; 20 1
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	6 19; 16 0; 12 14; 21 19
Y Cygni	48.1	+34 17	7. — 8.	1 12.0	7 12; 22 11; 13 23; 21 11
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	11 9; 21 11; 10 16; 20 19
VV Cygni	21 02.3	+45 23	11. —14.	1 11.4	12 22; 20 8; 11 11; 18 21
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	6 21; 16 14; 14 16; 24 8
UZ Cygni	55.2	+43 52	9. —11.5	31 07.3	10 2 10 9
RT Lacertæ	21 57.4	+43 24	9.1—10.5	5 01.7	10 9; 20 13; 9 20; 19 23
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	11 20; 22 5; 11 23; 22 8
TT Androm	23 08.7	+45 36	10.5—11.3	2 18.3	11 17; 20 0; 13 21; 22 4
32.1911 Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	10 9; 17 22; 9 12; 17 1
TW Androm.	23 58.2	+32 17	8.6—11.5	6 02.9	9 20; 18 2; 11 19; 20 1

Maxima of Variable Stars of Short Period not of the Algol Type.

[Calculated by Wallace F. Johnson at Goodsell Observatory]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h etc. An * following the name of a star signifies that for that star times of minima instead of maxima are given.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of maxima in July-August 1912. d h d h d h d h
SX Cassiop.	0 05.5	+54 20	8.6— 9·4	36 13.7	10 23; 14 13
SY Cassiop.	9.8	+57 52	9 3— 9.9	4 1.7	4 11; 20 18; 6 1; 22 7
RT Sculptor.*	0 31.5	−26 13	9.6—10.5	0 12.3	4 19; 25 6; 4 11; 24 22
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	2 8; 24 11; 4 12; 21 3
RW Cassiop.	1 30.7	+57 15	8.6— 9.4	14 19 2	9 7; 24 2; 7 22; 22 17
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	3 3; 21 0; 1 21; 25 17
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	5 2; 22 15; 3 7; 20 20
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	5 18; 23 23; 5 3; 23 8
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	1 17 2 18
SX Persei	4 10.2	+41 29	10.3—11.0	4 07.1	3 7; 20 11; 6 15; 23 19
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	4 23; 27 5; 7 8; 29 14
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	10 10; 22 1; 2 17; 25 23
TT Aurigæ*	02.8	+39 27	7.8— 8.7	0 16.0	1 16; 21 16; 4 0; 24 0
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	3 4; 21 13; 2 19; 21 4
SY Aurigæ	05.5	+42 42	9 0— 9.7	10 03.3	3 2; 23 9; 2 12; 22 19
Y Aurigæ	21.5	+42 21	9. —	3 20.6	4 9; 19 19; 4 6; 19 16
SV Tauri*	45.8	+28 05	9.4—11.0	2 04.0	2 23; 22 11; 4 11; 23 23
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	6 4; 22 18; 2 20; 24 22
RS Orionis	6 16.5	+14 43	7·8— 8.5	7 13 4	4 18; 19 21; 4 0; 19 3
T Monoc.	19.8	+ 7 08	6. — 8.	27 00.3	17 3; 13 3
RZ Camelop	23.7	+67 06	11.0—12.8	0 11.5	3 20; 23 1; 1 16; 25 16
W Gemin.	29.2	+15 24	6 8— 7.6	7 22.0	7 6; 23 2; 7 22; 23 18
ξ Gemin.	6 58.2	+20 43	3.7— 4.5	10 03.7	2 3; 22 10; 1 14; 21 21
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	18 1; 9 7
RR Gemin.	7 15.2	+31 04	9.7—10.6	0 09.5	4 9; 24 5; 1 4; 25 0
V Carinæ	8 26.7	−59 47	7.2— 8.0	6 16.7	2 3; 22 5; 4 15; 24 17
T Velorum	8 34.4	−47 01	7.5— 8.5	4 15.3	3 18; 26 23; 5 5; 23 19
W Carinæ	9 19.2	−55 32	7.5— 8.5	4 08.9	5 6; 27 2; 4 20; 26 16
S Antliæ*	27.9	−28 11	6.7— 7.8	0 07.8	7 8; 20 7; 2 7; 21 17
W Ursæ Maj.	9 36.7	+56 24	8.	0 04.0	1 17; 21 17; 4 2; 24 2
RR Leonis	10 02.1	+24 03	9.1—10.0	0 10.9	3 2; 26 20; 5 8; 24 8
ST Ursæ Maj.*	11 22.4	+45 44	6.7— 7.2	8 19.2	9 0; 26 14; 4 10; 22 0
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	4 4; 23 23; 6 4; 19 9
S Muscae	12 07.4	−69 36	6.5— 7.3	9 15.8	3 7; 22 14; 1 6; 20 14
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	3 3; 25 22; 6 8; 23 10
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	2 0; 22 5; 4 16; 24 21
R Crucis	18.1	−61 04	6.8— 8.0	5 19.8	4 6; 21 17; 2 9; 25 16
S Crucis	48.4	−57 53	6.6— 7.8	4 16 6	1 12; 24 13; 3 8; 22 2
RZ Centauri	12 55.6	−64 05	8.5— 8.9	0 22.5	2 2; 24 15; 1 3; 23 15
W Virginis	13 20.9	− 2 52	9.0—10.0	17 06.5	15 10; 1 16; 18 23
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	4 14; 25 15; 1 16; 22 17
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	4 2; 20 13; 5 23; 22 9
V Centauri	25.4	−56 27	6.7— 7.6	5 11.9	1 12; 23 11; 3 11; 25 10
RS Bootis	29.3	+32 11	8.9—10.	0 09.1	2 19; 25 10; 1 23; 17 1
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	1 11; 23 17; 7 12; 22 18
R Triang. Austr	15 10.8	−66 08	6.7— 7.7	3 09.3	6 12; 26 20; 2 15; 22 23
S Triang. Austr	15 52.2	−63 29	6.5— 7.5	6 07.8	4 17; 23 16; 5 7; 24 7
S Normæ	16 10.6	−57 39	6.5— 7.4	9 18.1	9 15; 29 03; 7 21; 27 9
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	2 13; 29 3; 6 23; 24 16
RV Scorpii	16 51.8	−33 27	6.8— 7.6	6 01.5	6 21; 25 2; 6 5; 24 9
u Herculis*	17 13.6	+33 12	5.1— 5.6	2 01 2	2 6; 20 17; 2 1; 20 12

Maxima of Variable Stars of Short Period not of the Algol Type.
Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean time of maxima in July-August 1912.					
	h m	° ′		d h	d h	d h	d h	d h	d h	
RV Ophiuchi*	17 29.8	+ 7 19	9.—< 11	3 16.5	7 9;	22 3;	5 21;	20 15		
X Sagittarii	41.3	−27 48	4.0— 6.0	7 00.3	7 15;	21 16;	4 16;	25 17		
Y Ophiuchi	47.3	− 6 07	6.2— 7.0	17 02.9		16 3;	2 6;	19 9		
W Sagittarii	17 58.6	−29 35	4.8— 5.8	7 14.3	3 23;	19 3;	3 8;	18 12		
Y Sagittarii	18 15.5	−18 54	5.8— 6.6	5 18.6	1 18;	24 20;	5 9;	22 17		
U Sagittarii	26.0	−19 12	7.0— 8.3	6 17.9	4 23;	25 5;	7 17;	27 22		
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	2 22;	23 15;	2 23;	23 16		
Y Lyrae	34.2	+43 52	10.5—12.	0 12.1	6 18;	24 21;	5 22;	24 1		
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	1 6;	26 20;	6 1;	26 12		
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	3 18;	23 13;	2 11;	22 7		
β Lyrae *	46.4	+33 15	3.4— 4.5	12 21.8	7 22;	20 20;	2 18;	28 14		
κ Pavonis	18 46.9	−67 22	4.0— 5.5	9 02.2	9 9;	27 13;	5 16;	23 20		
U Aquilae	19 24.0	− 7 15	6.4— 7.1	7 00.6	5 8;	19 9;	2 10;	23 12		
XZ Cygni	30.4	+56 10	8.7— 9.3	0 11.2	1 7;	24 14;	2 22;	26 6		
U Vulpec.	32.2	+20 07	6.9— 7.6	7 23.5	2 19;	18 18;	3 17;	19 16		
SU Cygni	40.8	+29 01	6.6— 7.4	3 20.3	2 16;	18 2;	2 11;	17 20		
η Aquilae	47.4	+ 0 45	3.5— 4.7	7 04.2	1 4;	22 16;	6 1;	20 9		
S Sagittae	51.5	+16 22	5.6— 6.4	8 09 2	4 4;	20 23;	6 17;	23 11		
X Vulpec.	19 53.3	+26 17	8.5— 9.1	6 07.7	3 7;	22 6;	3 21;	22 20		
XX Cygni	20 01.3	+58 40	10.5—11.5	0 03.2	2 20;	23 1;	5 13;	19 0		
V Vulpec. *	32.3	+26 15	8.0— 9.0	37 19.0	1 28;		8 13			
X Cygni	39.5	+35 14	6.4— 7.7	16 09 3	12 4;	28 14;	13 23;	30 8		
T Vulpec.	47.2	+27 52	5.5— 6.5	4 10 5	1 13;	23 17;	1 14;	23 19		
WZ Cygni *	49.3	+38 27	9.8—10.8	0 14.0	4 21;	22 10;	3 3;	20 15		
WY Cygni	52.3	+30 03	9.5—10.3	0 13.5	1 9;	23 19;	4 0;	20 20		
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	1 8;	23 18;	1 16;	24 1		
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	6 13;	21 6;	4 23;	19 17		
VY Cygni	21 00.4	+39 34	8.9— 9.5	7 20.6	1 9;	17 2;	1 20;	17 13		
VZ Cygni	21 47.7	+42 40	8.4— 9.2	4 20.7	2 2;	26 10;	5 3;	24 14		
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.6	4 3;	21 11;	7 18;	25 1		
δ Cephei	25.5	+57 54	3.7— 4.9	5 08.8	1 2;	22 13;	2 7;	23 18		
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	1 5;	22 23;	2 20;	24 14		
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	5 1;	24 8;	6 4;	25 10		
V Lacertae	44.5	+55 48	8.2— 8.9	4 23.6	2 15;	22 13;	1 12;	26 10		
X Lacertae *	22 45.0	+55 54	8.2— 8.6	5 10.6	5 18;	22 1;	1 23;	23 17		
SW Cassiop.	23 03.7	+58 12	9.2— 9.7	5 10.6	1 22;	23 15;	3 12;	25 6		
RS Cassiop.	32.6	+61 52	9.1—10.0	6 07.1	2 19;	21 16;	3 7;	22 4		
RY Cassiop.	47.2	+58 11	9.2—10.0	12 03.4	4 19;	29 2;	10 6;	22 9		
U Pegasi	23 52.9	+15 24	9.0— 9.7	0 04.5	7 15;	22 15;	6 15;	21 15		

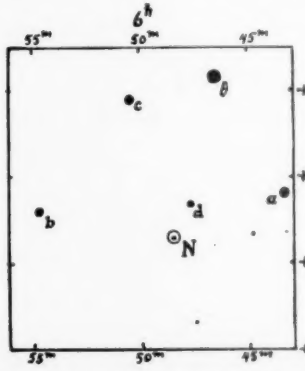


Fig. 1. Region about Nova Geminorum as seen with field-glasses.

Nova Geminorum No. 2.—In my observations of the Nova with a pair of field glasses of 2 inches aperture I have used the comparison stars shown in Fig. 1, in addition to the more distant stars κ, ι, υ and τ Geminorum. Their magnitudes as found in Harvard Annals, Vol. L, are as follows:

Star	Mag.	Star	Mag.
θ	3.64	a = BD.+ 32° 1414	5.76
κ	3.69	b = BD.+ 32 1460	6.46
ι	3.89	c = BD.+ 33 1433	6.01
υ	4.22	d = BD.+ 32 1433	...
τ	4.48		

The star b has a companion, BD. + 32° 1458, of magnitude 8 3, so that its apparent brightness as seen in the field-glasses on a moonless night

was increased about 0.3 magnitude. In my sequences made on moonless nights *b* was generally brighter than *c*, but in moonlight *c* generally appeared brighter than *b*, so that it is probably best to reject the comparison stars with star *b*.

The observed sequences are as follows:

	C.S.T.	Sequence		Magnitude
Mar. 14	8:00	$N\ 2\ \theta$		3.5
	10:00	$N\ 1\ \theta$		3.6
	11:00	$N = \theta$		3.6
	12:30	$\theta\ 1\ N$		3.7
15	8:15	$\theta = \kappa\ 2\ \iota\ 2\ \nu\ 5\ \tau\ 5\ N$		4.9
18	8:20	$\theta\ 10\ \tau\ 10\ N\ 5\ a\ 2\ b\ 1\ c\ 3\ d$		5.3
	11:00	$\theta\ 10\ \tau\ 10\ N\ 5\ a\ 3\ b\ 1\ c\ 3\ d$		5.3
19	9:35	$\theta\ 10\ \tau\ 10\ N\ 3\ a\ 2\ b\ 1\ c\ 10\ d$		5.5
21	9:25	$\theta\ 15\ \tau\ 8\ N\ 3\ a\ 1\ b\ 2\ c\ 5\ d$		5.5
22	10:27	$\theta\ 15\ \tau\ 7\ N\ 7\ a\ 1\ b\ 2\ c\ 10\ d$		5.2
23	7:30	$\tau\ 5\ N\ 10\ a = c\ 1\ b\ 10\ b$		5.0
	10:00	$\tau\ 3\ N\ 12\ a$		4.8
26	8:00	$\tau\ 15\ N = a\ 3\ c\ 1\ b$	In moonlight	5.8
	10:00	$a\ 1\ N$		5.9
28	10:20	$\tau\ 15\ a\ 1\ N\ 5\ c\ 1\ b\ 5\ d$	Moonlight	5.8
Apr. 2	9:40	$\tau\ 14\ N\ 1\ a\ 5\ c\ 2\ b$	"	5.6
3	9:10	$\tau\ 13\ N\ 2\ a\ 2\ c\ 2\ b\ 5\ d$	Very clear	5.6
8	8:48	$a\ 1\ b\ 2\ N\ 2\ c\ 2\ d$	" "	5.9
9	10:00	$a = b\ 2\ N\ 1\ c\ 5\ d$	" "	5.9
10	9:00	$a\ 1\ b\ 1\ N\ 2\ c\ 5\ d$		5.9
18	9:50	$a\ 1\ b\ 2\ N\ 2\ c\ 5\ d$		5.9
19	10:25	$a\ 1\ b\ 1\ N\ 1\ c\ 5\ d$		5.9
23	9:55	$a\ 3\ b\ 1\ c\ 2\ N\ 3\ d$	In moonlight	6.4
May 6	9:45	$a\ 3\ b\ 1\ c\ 5\ d\ 5\ N$		7.4
8	8:55	$a\ 3\ b\ 1\ c\ 3\ d\ 2\ N$		7.2

On May 16 the nova was too faint to be observed readily with the field-glasses and the following sequence was obtained with the 5-inch finder of the 16-inch equatorial. Another sequence was observed on Mar. 23. The comparison stars are indicated upon Fig. 2.

Fig. 2. Telescopic view of the region within a half degree of the Nova.

May 16	9:45	$d\,8\,N\,8\,e\,2\,f = g\,2\,h = k\,5\,l$	7.5
23	8:55	$d\,7\,N\,7\,e\,2\,f = g\,1\,h\,3\,k\,5\,l$	7.5

The magnitudes of these stars as given by the BD. and those resulting from my sequences, adopting mag. 7.0 for star *d*, are as follows:

Star	Mag. BD.	Magnitudes from Sequences May 16	May 23	Mean
d = BD. + 32° 1433	7.0	7.0	7.0	7.0
e = BD. + 32 1437	8.0	8.3	8.1	8.2
f = BD. + 32 1442	8.6	8.4	8.3	8.4
g = BD. + 31 1442	8.6	8.4	8.3	8.4
h = BD. + 32 1441	8.7	8.6	8.4	8.5
k = BD. + 32 1434	8.6	8.6	8.6	8.6
l = BD. + 32 1436	8.9	9.0	9.0	9.0

These charts and magnitudes may be of use to observers who wish to follow the changes of the nova during June.

H. C. Wilson.

Four Missing Stars.—In *A. N.* 4567 A. A. Nijland of Utrecht calls attention to four of the BD. stars which are now missing from the sky. Each of these was observed in two different zones of the BD. so that their positions are probably not erroneous. The stars are

BD.	Mag.	α 1855	δ 1855
		h m s	° ′
+ 13 555	9.5	3 20 59.2	+ 13 57.5
+ 13 559	9.5	3 22 04.6	+ 13 59.3
+ 13 562	9.5	3 22 18.0	+ 13 50.0
+ 45 639	9.4	3 28 20.3	+ 45 54.3

It will be well for observers to look up these positions occasionally, for the stars may be long period variables.

Suspected Variable 22.1912 Geminorum.—In *A.N.* 4568 Mr. A. Bemporad, of Catania, calls attention to suspected variations of the star BD + 32° 1414 ($5^m.8$). This is the star about a degree west and a half degree north of Nova Geminorum, and has doubtless been used as a comparison star for the Nova by many observers. Its color is quite red, so that we may look upon small observed variations with suspicion as to their reality. Mr. Bemporad finds a range of from $6^m.3$ to $0^m.5$ in a period of possibly 8 days.

COMET AND ASTEROID NOTES.

New Elements of Encke's Comet.—I have just finished a new orbit for Encke's comet based upon three normal positions taken from a recent number of the *Nachrichten*. The periodic time still decreases. It has decreased two days and one hour since 1900. It will be very favorably situated for observation at its next return, in 1914. It will be circumpolar here ($\phi = +41° 49'$) from about Oct. 4–Oct. 29, and will be nearer the earth the last week in Oct. (1914) than it has been for many years, and should be visible to the naked eye. I enclose you elements, constants and search ephemeris for 1914.

Encke's Comet.

EPOCH AND OSCULATION 1911 Sept. 15.5 G.M.T.

	°	′	″
M =	8	12	29.1
φ =	57	54	57.29
Ω =	334	29	32
π =	159	9	1.20
i =	12	34	31.8

$\log a = 0.34554$
$\log q = 9.52943$
$\mu = 1075''.6682$
$P = 1204.800$ days

Next perihelion about Dec. 5.891, 1914.

	°	′	″

$x = r\,[9.99809]\ \sin(249\ 41\ 12.33 + v)$
$y = r\,[9.91516]\ \sin(155\ 57\ 13.30 + v)$
$z = r\,[9.76072]\ \sin(167\ 21\ 34.23 + v)$

Search Ephemeris for Encke's comet Sept. 25–Nov. 4, 1914.

1914	α h	m	s	δ °	′	″	log r	log Δ
Sept. 25	3	58	52	+41	51	9	0.15746	9.84514
Oct. 3	4	29	24	+47	45	31	0.12202	9.74325
" 11	5	27	53	+55	48	35	0.08142	9.62656
" 19	7	54	48	+63	14	8	0.03408	9.50768
" 27	11	34	59	+52	34	49	9.97764	9.44433
Nov. 4	13	16	57	+28	2	50	9.90944	9.50108

F. E. SEAGRAVE.

PROVIDENCE, April 27, 1912.

Minor Planet 1911 MT.—The minor planet 1911 MT discovered by Palisa at Vienna on Oct. 3, 1911, is so unique an object, that every effort should be made toward the determination of its orbit. We reprint below the preliminary note in the *Lick Observatory Bulletin* No. 210, showing the remarkable success which the computers at Berkeley (University of California) have had, using the very meager data of two nights observations. It is to be hoped that with the aid of the ephemeris here given the planet may be found upon other photographic plates taken before or after Oct. 3.

Preliminary Note on the Orbit of Minor Planet 1911 MT.—The first and third of the observations given below were published in *A.N.* No. 4528–29 and were also received at the Students' Observatory by telegraph at the time of discovery. Having unfortunately overlooked, until after the completion of our orbit computation, the second observation which was published in *A. N.* No. 4530, we did not become aware of the existence of additional observations until the receipt in January of *A. N.* 4545, containing Ebell's report on his orbit computation. Professor Leuschner then wrote to Professor Palisa for all the observational material. In response Professor Palisa recently furnished the following revised positions:

	Date 1911	Local M.T. h m s	App. α h m s	App. δ ° ′ ″	Observer
(1)	Oct. 3	14 51 56.0	0 42 04.83	+0 15 40.8	Palisa, Vienna
(2)	Oct. 4	10 49 41.3	0 43 43.30	−0 12 48.9	Palisa, Vienna
(3)	Oct. 4	14 11 03.0	0 43 58.99	−0 17 50.8	Pechule, Copenhagen
(4)	Oct. 4	15 07 05.0	0 44 03.14	−0 19 12.5	Pechule, Copenhagen

The application of Leuschner's method, including the complete elimination of the parallax,* to the first, second, and fourth of these observations, yielded the following two orbits as a result of the direct solution:

Elements I		Elements II	
T	1911, Aug. 25.0876, G.M.T.	T	1911, Sept. 5.3759, G.M.T.
ω	146° 59′ 10″	ω	159° 3′ 32″
Ω	185 29 48 (1911.0)	Ω	185 19 0 (1911.0)
i	8 15 24	i	8 16 41
e	0.434982	e	0,365273
μ	1259″.08	μ	1428″.23
a	1.99512	a	1.83431
Period	2.818 years	Period	2.484 years

Constants for the Equator 1911.0	Constants for the Equator 1911.0
$x=r$ [9.999953] sin(62° 25′ 04″ + v)	$x=r$ [9.999962] sin(74° 19′ 13″ + v)
$y=r$ [9.985680] sin(332 11 49 + v)	$y=r$ [9.984521] sin(344 06 45 + v)
$z=r$ [9.403207] sin(335 39 01 + v)	$z=r$ [9.419355] sin(347 07 48 + v)

O−C	1	3	4	O−C	1	3	4
	″	″	″		″	″	″
cos δ Δα	−2.1	(+0.6)	+0.6	cos δ Δα	− 5 8	(+1.8)	+1.0
Δδ	+1.4	(+5.6)	+2.6	Δδ	+11.8	(+5.7)	+2.4

It is interesting to note that without elimination of the parallax the olution of the orbit would not have been possible.

The residuals of the third observation, which was not used in the orbit computation, are given with those of the first and fourth observations on which the solutions were based. In the nature of the solution the second observation is, of course, accurately represented. The residuals of the first orbit are entirely satisfactory except that the declination residuals are all of the same sign. The declination residual of the first observation for the second orbit is too large in comparison with the probable error of observation. As the preliminary analysis of the conditions of the problem indicated that this residual could not be accounted for by the neglected third differences of the motion, the second solution might have been discarded and a search ephemeris computed merely from the first orbit. In order to further test the reality of the second solution and to possibly improve the orbits by the removal of the residuals an independent differential correction of both orbits was undertaken. Both orbits then converged to the same result within the accuracy of the solution. In this differential correction the mean of the residuals of the third and fourth observations was adopted as the residual for the fourth observation.

The residuals after the separate differential correction of the two orbits are as follows:

I

O−C	1	½(3+4)	3	4
cos δ Δα	+4″.1	−0″.2	(−0″.3)	(−0″.1)
Δδ	+1 .5	+0 .2	(+2 .3)	(−1 .9)

II

O−C	1	½ (3+4)	3	4
cos δ Δα	+4″.1	+0″.6	(+0″.8)	(+0″.4)
Δδ	+1 .3	+0 .4	(+2 .3)	(−1 .4)

The first set of residuals correspond to the following adopted elements:

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* Klinkerfues *Theoretische Astronomie*, Dritte Ausgabe von H. Buchholz, 82. Vorlesung; cf. also Anhang, Fünftes Beispiel, pages 1037 to 1045.

ADOPTED ELEMENTS.

$T = 1911$, Aug. 20.7480, G.M.T.
$\omega = 141° 20' 27''$
$\Omega = 185\ 35\ 59$ } 1911.0
$i = 9\ 31\ 23$
$e = 0.509369$
$\mu = 1050''.06$
$a = 2.25179$
Period = 3.379 years

CONSTANTS FOR THE EQUATOR 1911.0.

$x = r\,[9.999944] \sin(56° 51' 51'' + v)$
$y = r\,[9.986960] \sin(326\ 38\ 2 + v)$
$z = r\,[9.383749] \sin(330\ 34\ 35 + v)$

The foregoing residuals indicate that there is a relative error of observation of from 3 to 4 seconds in the declinations of the third and fourth places; that the difference between the elements (I) of the direct solution and the adopted elements approximately represents the uncertainty of the solution; that the observations do not admit of an exact representation, owing to errors of observation, provided the perturbations due to the earth be considered negligible.

From the adopted elements we have computed the following ephemeris for 1911.0:

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT

1911	α h m	δ ° ′	Δ	Mag.
Sept. 1.5	22 15.8	+31 03	0.1318	10.7
9.5	23 11.1	22 45	0.1359	
17.5	23 53.2	13 44	0.1515	11.1
Sept. 25.5	0 22.4	6 00	0.1779	
Oct. 3.5	42.0	+ 0 19	0.2140	12.0
11.5	0 55.2	− 3 29	0.2585	
19.5	1 4.6	5 47	0.3112	12.9
Oct. 27.5	12.0	6 56	0.3718	
Nov. 4.5	18.7	7 15	0.4403	13.8
12.5	25.2	6 58	0.5167	
Nov. 20.5	1 32.0	− 6 15	0.6010	14.6

The ephemeris was computed for about a month before discovery in the hope that the object may be found on plates taken previous to the discovery. An ephemeris corresponding to the first direct solution would require the following corrections to the adopted ephemeris:

Sept. 1.5	+ 27ᵐ.5	−4° 41′
Oct. 3.5	00 .0	0 00
Nov. 20 5	+ 03 .2	−0 23

Since the difference between the ephemerides on November 20 is only 3ᵐ.2 and 23′ it should not be difficult to locate the object on any plates that may be available for this purpose.

Observers are requested to search available plates without delay and to notify the Student's Observatory by telegraph in case the object be found and forward their detailed photographic positions by mail. If no telegram is received at the Student's Observatory announcing the finding of the object before June 1, another solution of the orbit will be undertaken by including the attraction of the earth in the direct solution.

E. S. HAYNES.
J. H. PITMAN.

Berkeley Astronomical Department, April 20, 1912.
Lick Observatory Bulletin No. 210.

NOTES FOR OBSERVERS.

No comet yet discovered this year! Some of our amateurs have a splendid chance to win the honor of being the first to see a new comet this summer. Who is it to be?

Planetary and Lunar Section.—Mr. Charles E. Niles of Seneca has resigned the directorship of the Planetary and Lunar section of the S. P. A. and Mr. Latimer J. Wilson of 1405 Gartland Ave, Nashville. Tenn., has resumed that position.

The Monthly Report of the American Association of Variable Star Observers.—It is a pleasure to report that the progress the Association is making is most encouraging to all concerned. A total over six hundred observations of 97 variable stars are included in this months report, seventeen observers coöperating in an observational record to be proud of.

Two new members have lately signified their desire to join our Association. Their names and addresses are as follows:—

Mr. Alan P. C. Craig, Corona, Cal.

Mr. Edward A. Perkins, Lynn. Mass.

Their respective initial letters C and P, will indicate in future reports observations made by them.

Special mention must be made of the work of Mr. J. B. Lacchini, our Italian observer. He took up this line of observational work only a few months ago, but has made such rapid progress that he was able to send in this month one hundred and forty eight observations, remarkable for their accuracy. This shows what diligence and perseverance can accomplish. Mr. Lacchini is to be congratulated on his success, and his zeal should inspire us all.

The observations of 094211 R Leonis are worthy of note, as during the past month the variable has attained naked-eye brilliance. The calculated date of maximum, according to Hartwig, was May 1, which concurs closely with the obsecved date. Dr. Gray's estimate of 4.6, May 2, was the brightest recorded by our observers. This estimate if correct is interesting, as exceeding by .6 of a magnitude the star's brightest maximum. This variable was discovered by Koch in 1782, and is red in all phases of its light. It is easily observed and estimated at present wsth binoculars.

That extremely interesting variable 154428 R Cor. Bor. has been closely followed the past month by nine of our observers, the observations being well in accord. This star should be observed frequently by all, as it is subject to remarkable and sudden changes.

The variable 164715 S Herculis is displaying irregularity. Hartwig's date of maximum is April 29. Two identical observations on May 3 indicate that the varlable on the calculated date of maximum was approximately a tenth magnitude star, which is about four magnitudes fainter than its given brightness at maximum.

A minimum of the variable 081112 R Cancri, calculated by Hartwig for April 17, appears to be incorrect, as the star has been rising during the past month, and on the date of calculated minimum was approximately a ninth magnitude star.

VARIABLE STAR OBSERVATIONS Apr. to May. 1912.

001755
T Cassiopeiae
Mo. Day Est. Obs
4 10 9.0 Y
24 9.1 L
29 9.9 J
26 9.0 L
5 5 8.9 J

004958
W Cassiopeiae
4 19 9.7 J
25 10.0 J
5 5 10.2 J

011272
S Cassiopeiae
4 13 11.2 B

024315
W Persei
4 8 9.8 V
15 9.9 V

032043
Y Persei
4 10 8.4 Su
20 8.4 Su
30 8.4 Su

032319
R Persei
4 10 10.6 Y

042215
W Tauri
4 5 9.8 G

042309
S Tauri
4 10 10.3 Fu

043065
T Camelop.
4 10 8.2 Y
20 8.2 Y
5 3 8.5 Y

043274
X Camelop.
4 10 10.3 O
10 9.8 Y
16 8.5 O
20 8.1 O
20 8.3 Y
5 3 8.2 Y

044617
V Tauri
4 10 8.9 Fu

045514
R Leporis
3 29 7.2 L
4 3 6.5 G
4 7.5 L
4 6.6 G
5 6.5 G
6 6.7 F
8 6.5 F

R Leporis
Mo. Day Est. Obs.
4 8 7.7 L
10 7.4 L
11 6.3 G
15 6.8 F
17 6.1 G
21 6.2 F

050022
T Leporis
4 4 10.6 G

050003
V Orionis
4 10 10.4 Fu
20 10.1 Fu

050953
R Aurigae
4 19 11.6 J
23 11.5 J
29 11.0 Ha
5 3 11.2 J

052034
S Aurigae
4 25 9.3 Y

052404
S Orionis
4 10 10.0 Fu

053068
S Camelop.
4 10 8.3 Y
20 8 4 Y
27 8.7 Y
5 3 8.8 Y

053531
U Aurigae
4 25 10.0 Y

054920
U Orionis
4 6 8.8 F
15 8.3 F
17 7.8 G
20 7.0 Fu
21 7.5 F

055353
Z Aurigae
4 10 9.5 Y
27 9.9 Y

060450
X Aurigae
4 10 10.2 Su
20 9.2 Su
30 8.7 Su

061702
V Monoc.
20 8.5 G

064030
X Gemin.
4 11 8.6 Su

065355
R Lyncis
Mo. Day Est. Obs.
4 19 10.6 J
23 10.8 J
25 10.2 Y
30 11.0 J
5 3 10.9 J

070122
R Gemin.
4 20 12.2 Hu

070310
R Can. Min.
4 5 10.0 V
10 10.8 O
14 10.1 V

072708
S Can. Min.
3 28 8.3 L
29 8.3 L
30 8.2 L
4 3 8.2 L
4 7.9 G
4 8.1 L
5 8.0 F
6 7.8 G
6 8.0 L
7 7.9 L
8 7.8 Ha
9 7.8 G
10 7.9 L
11 7.6 G
11 7.8 L
13 7.7 B
13 7.5 Ha
14 7.7 M
15 7.4 F
16 7.7 O
18 7.6 L
19 7.6 M
20 7.6 F
20 7.7 G
20 7.6 O
21 7.8 L
21 7.4 M
22 7.8 L
22 7.6 Ha
23 7.8 L
24 7.6 L
24 7.4 G
24 7.3 M
25 7.7 B
25 7.8 L
26 7.8 L
26 7.6 G
26 7.5 Ha
27 7.2 M
29 7.4 Ha
5 2 7.3 G
2 7.6 Ha
5 7.7 Ha

072811
T Can. Min.
Mo. Day Est Obs.
4 10 11.2 Fu
19 10.8 Fu
30 10.5 Su

073508
U Can. Min.
4 10 9.9 O
16 9.5 O
20 9.5 O
20 9.3 Y
27 9.0 Y
5 4 9.0 Y

074922
U Gemin.
4 14 12.0 V

081112
R Cancri
4 5 10.1 F
8 9.4 V
9 9.6 F
15 8.7 V
15 8.9 F
16 9.4 O
20 9.0 O
20 9.0 F
5 3 8.3 Y
4 8.9 Y

081617
V Cancri
4 16 9.1 O
16 9.0 Su
25 8.4 Su
5 2 8.3 Su

082405
RT Hydrae
4 8 7.7 V
10 8.2 O
15 8.3 V

084803
S Hydrae
4 10 10.0 O
16 9.9 O
20 9.7 O
20 9.6 P
23 8.9 Hu
5 4 8.9 O

085120
T Cancri
4 3 9.5 L
4 9.4 L
5 8.8 V
6 9.5 L
10 9.6 L
11 9.5 L
11 9.0 G
13 9.5 L
14 8.8 V
20 9.3 O
20 8.9 V
23 9.4 L
26 9.4 L

093934
R Leo. Min.
Mo. Day Est. Obs.
4 16 10.5 Hu
23 10.0 Hu
5 3 10.5 P

094211
R Leonis
3 28 6.5 L
30 6 4 L
4 3 6.3 L
3 5.9 G
4 6.1 L
5 6.2 V
6 6.0 L
6 5.7 G
7 6.0 L
7 6.5 F
8 6.0 L
10 6.3 Su
10 5.9 L
11 5.7 G
11 5.7 L
13 5.8 Ha
13 5.7 L
14 5.6 G
14 5.3 V
16 5.5 O
18 5.2 C
18 5.6 Ha
20 5.4 V
20 5.2 C
20 5.4 O
20 5.0 G
20 6.0 Su
21 5.6 L
22 6.0 D
22 5.6 L
22 5.4 Ha
23 5.3 L
24 5.2 L
25 5.2 L
26 5.2 L
26 4.8 G
29 5.2 Ha
29 4.8 G
5 2 5.9 Su
2 4.6 G
4 5.5 O
5 5.5 Ha

095421
V Leonis
4 10 10.5 Su
20 11.5 Su

103012
U Hydrae
4 7 5.8 F
21 5.6 F

VARIABLE STAR OBSERVATIONS Apr. to May, 1912—Continued.

103769
R Urs. Maj.

Mo.	Day	Est.	Obs.
4	5	11.0	F
	8	12.1	L
	9	11.0	F
	10	12.2	Su
	19	12.3	B
	25	12.5	Y
5	4	12.5	Y

105517
R Crateris

4	3	9.0	G
	4	8.8	G
	7	8.4	F
	9	8.5	F
	11	9.0	G
	15	9.2	G
	21	8.0	F

110506
S Leonis

4	11	9.9	Su
	20	10.3	Y
	20	9.8	Su
	27	10.0	Y
5	3	10.6	Y

121418
R Corvi

4	18	11.6	G
	20	11.0	Hu

122001
SS Virginis

4	10	7.0	O

122532
T Can. Ven.

4	8	11.2	V
	11	10.7	Fu
	15	11.2	V
	25	10.4	Y
5	3	10.2	Y
	3	10.4	Y
	4	10.5	Fu

123160
T Urs. Maj.

4	10	7.3	O
	10	7.8	Su
	11	8.2	D
	13	7.3	Ha
	16	8.0	O
	19	8.2	J
	20	8.2	Su
	20	8.0	O
	21	8.5	D
	23	8.5	O
	23	8.2	J
	24	8.5	L
	25	8.3	Su
	25	8.1	B
	25	8.2	Y

T Urs. Maj.

Mo.	Day	Est.	Obs.
4	26	8.5	L
	30	8.8	D
	30	8.7	J
	30	8.5	Hu
5	2	8.4	Su
	3	8.9	O
	3	8.7	J
	4	8.8	Y

123307
R Virginis

4	20	11.8	Hu
	20	11.6	V

123961
S Urs. Maj.

3	29	8.5	L
4	3	8.8	L
	4	8.7	G
	6	8.7	L
	6	8.8	F
	7	8.1	V
	10	8.9	O
	10	8.5	L
	13	8.3	Ha
	15	8.3	V
	15	8.5	G
	15	8.3	Ha
	16	8.8	O
	17	8.4	G
	18	8.3	G
	19	8.3	J
	19	7.8	M
	20	8.5	O
	20	8.4	G
	21	8.4	G
	21	8.7	D
	21	7.7	M
	23	8.4	J
	23	8.6	O
	23	8.3	Hu
	23	8.3	L
	24	8.3	L
	24	7.8	G
	24	7.7	M
	25	8.5	Y
	26	8.1	Ha
	26	8.3	L
	26	7.8	J
	27	8.0	Hu
	27	7.5	M
	29	7.9	Ha
	29	7.7	G
	30	7.8	B
5	2	7.8	Ha
	2	8.0	V
	2	8.0	G
	2	7.4	M
	3	8.3	O
	3	8.6	J
	3	8.0	B
	4	7.9	V
	4	8.4	Y

124213
RU Virginis

Mo.	Day	Est.	Obs.
4	10	9.1	V
	18	9.3	V

124606
U Virginis

4	10	8.7	O
	10	8.7	S
	11	8.2	Su
	20	7.8	Su
	20	8.2	O
5	3	7.8	Su

132202
V Virginis

4	11	9.8	Su
	20	9.9	Su

132422
R Hydrae

4	4	7.0	G
	6	7.6	L
	7	7.1	F
	8	7.5	L
	13	7.7	L
	14	7.8	G
	21	7.0	F
	22	7.8	L
	23	7.9	L
	24	7.7	G
	25	7.8	L

132706
S Virginis

4	8	11.3	L
	10	11.1	L

133273
T Urs. Min.

4	11	9.0	Fu

073723
S Gemin.

4	9	10.1	Fu

134440
R Can. Ven.

4	9	11.7	S

141567
U Urs. Min.

4	19	8.9	J
	23	8.8	J
	28	8.9	J
	30	9.0	J
5	3	8.9	J

142205
RS Virginis

4	10	11.8	V
	18	11.8	V

142539
V Boötis

Mo.	Day	Est.	Obs.
3	29	8.2	L
4	3	8.1	G
	6	8.0	L
	7	7.9	F
	8	9.0	F
	10	7.3	N
	10	8.2	L
	14	8.2	G
	15	8.3	G
	18	7.9	V
	20	8.4	G
	22	8 2	L
	23	8 0	O
	26	8.3	L
	29	8.2	G
5	4	8.2	V

142584
R Camelop

4	13	12.2	B
5	3	12.9	B

143227
R Boötis

3	29	7.9	L
4	6	8 0	L
	10	8.0	O
	10	8.2	L
	12	8.2	L
	20	8.4	O
	24	8.4	L

144139
RR Boötis

5	4	9.8	Fu

150605
Y Librae

4	23	8.8	Hu

151731
S Cor. Bor.

4	4	7.7	G
	10	8.3	O
	14	8.0	G
	20	8.6	O
5	2	8.7	G

153378
S Urs. Min.

4	3	10.8	L
	4	10.8	L
	7	11.2	L
	8	11.3	L
	10	11.6	L
	10	11.3	L
	18	11.7	L
	23	11.6	L

154428
R Cor. Bor.

Mo.	Day	Est.	Obs.
4	4	7.1	G
	5	6.9	G
	6	7.2	F
	8	7.2	Ha
	9	7.2	F
	9	7.3	S
	10	7.2	O
	11	7.2	G
	14	7.0	G
	16	7.3	Su
	16	7.3	O
	18	7.0	G
	19	7.0	J
	20	7.2	Y
	20	7.2	O
	20	7.5	Su
	20	6.8	G
	22	7.0	Ha
	23	7.2	O
	23	7.3	J
	24	7.1	L
	24	7.0	G
	25	7.0	L
	25	7.2	O
	26	7.2	L
	26	7.1	G
	27	6.8	J
	27	7.4	Y
	29	6.9	G
5	2	7.2	G
	3	7.5	O
	3	7.2	J
	4	7.9	Y

155823
RZ Scorpii

4	16	11.5	G

155847
X Herculis

3	30	6.4	L
4	4	6.5	L
	7	6.6	L
	10	6.5	L
	22	6.5	L
	22	6.0	C
	26	6.3	L

162112
V Ophiuchi

4	7	8.5	F
	15	7.5	G

162119
U Herculis

4	4	9.6	G
	8	10.2	Ha
	20	10.0	Y
	20	10.4	G
	24	10.6	G
	25	10.5	O
5	2	11.5	G
	3	10.4	Y
	5	10.6	Ha

VARIABLE STAR OBSERVATIONS Apr. to May 1912—Continued.

163172
R Urs. Min.

Mo.	Day	Est	Obs
4	10	10.5	O
	10	9.8	B
	16	10.6	O
	20	10.5	O

163137
W Herculis

4	20	10.8	Y
5	3	9.6	Y

163266
R Draconis

4	3	6.9	G
	4	7.2	L
	6	7.2	L
	10	7.4	L
	10	7.4	O
	11	7.2	B
	15	8.0	M
	16	7.4	O
	19	7.6	J
	20	7.4	O
	22	7.7	L
	23	7.9	J
	25	7.5	B
	25	7.7	O
	25	7.8	L
	25	7.9	Y
	27	7.4	M
	38	8.1	J
	30	7.9	O
5	2	7.2	M
	3	7.9	O
	3	8.1	J
	4	8.0	Y

164715
S Herculis

4	19	9.7	J
	23	10.0	J
5	3	9.9	J
	3	9.9	O

165030
RR Scorpii

4	13	9.7	G

165631
RV Herculis

4	25	10.1	O

170215
R Ophiuchi

Mo.	Day	Est.	Obs.
4	6	8.3	L
	7	8.2	F
	10	8.2	L
	15	8.4	G
	19	8 6	G
	20	9.0	F
	20	8.6	L
	21	8.5	J
	22	8.8	L
	22	9.0	G
	25	9.1	J
	26	9.0	L

181136
W Lyrae

4	20	8.3	Y
	27	7.8	Y
5	3	7.0	O
	4	7.6	Y

184105
R Scuti

4	8	5.5	F
	15	5.1	G
	19	4.8	G
	20	5.7	F
	22	4.8	G

193449
R Cygni

4	4	10.3	L
	5	10.0	F
	7	9.8	F
	8	10 6	Ha
	11	10.9	L
	13	10.6	G
	14	10.0	F
	15	11.0	G
	15	10.8	M
	20	11.2	L
	20	10.2	F
	22	11.0	Ha
	23	10.5	F
	25	11.2	L
5	5	11.5	Ha

194048
RT Cygni

Mo.	Day	Est.	Obs.
4	4	8.8	L
	5	8.6	F
	6	9.0	L
	7	8.7	F
	8	9.1	L
	11	9.2	L
	13	8.8	G
	14	9.0	F
	15	9.3	G
	20	9.6	L
	20	9.3	F
	23	9.8	L
	25	9.8	L

194248
TU Cygni

4	7	9.3	F
	20	9.2	F

195849
Z Cygni

4	22	9.3	G

200938
RS Cygni

4	15	8 4	G
	21	9.1	J
	22	8 2	G
	25	8.9	J
5	4	9 0	J

201008
R Delphini

4	21	9.0	J
	25	8.6	J

201647
U Cygni

4	4	7.9	L
	6	7.9	L
	7	7.5	F
	10	7.9	L
	14	7.4	F
	15	7.4	G
	19	7.7	G
	20	8.0	L
	20	7.6	F
	21	7.6	J
	22	7.7	G
	23	8.0	L

U Cygni

Mo.	Day	Est.	Obs.
4	25	7.7	J
	25	7.9	L
5	3	8.0	J

204405
T Aquarii

4	21	9.0	J
	25	8.7	J
5	5	8.4	J

210868
T Cephei

3	30	9.8	L
4	4	9.9	L
	6	9.5	L
	7	9.7	L
	8	9.8	L
	10	9.7	L
	11	9.7	L
	11	8.5	B
	20	9.1	L
	23	9.0	L
	23	9.2	J
	24	9.0	L
	25	9.4	J
	25	9.0	L
	27	8.3	B
5	3	8.8	J
	5	8.1	Ha

213044
W Cygni

4	16	5.0	G
	26	6.1	L

213553
RU Cygni

4	16	9.1	G

213678
S Cephei

4	10	7.7	B
	11	7.7	B
	23	8.9	J
	27	7.9	B
5	3	9.0	J

213843
SS Cygni

4	25	11.9	J

213937
RV Cygni

4	8	6.8	F
	16	7.0	G
	19	6.9	G

230759
V Cassiopeiae

Mo.	Day	Est.	Obs.
4	25	11.8	J

235350
R Cassiopeiae

4	10	9.9	L
	24	9 0	L
	25	8.7	J
	26	8.9	L
5	5	8.0	J

064932
NOVA GEMIN. No. 2.

3	28	5.9	L
	29	6.0	L
	30	5.6	L
	30	5.5	L
4	3	5.8	L
	4	5.9	L
	6	6.0	L
	7	5.9	L
	8	5.9	L
	10	6.5	O
	10	6.3	L
	11	6.5	L
	11	6.7	Fu
	12	6.2	L
	13	6.5	L
	16	6.2	Su
	16	6.9	O
	19	6.2	Fu
	19	6.6	J
	20	6.9	O
	20	6.6	Fu
	21	7.0	L
	22	6.9	L
	23	6.9	O
	23	6.9	L
	24	6.8	L
	24	6.7	G
	25	7.0	L
	26	6.7	G
	26	7.0	L
	26	6.8	Ha
	27	7.0	Y
	29	6.8	G
5	2	6.9	G
	2	6.8	Ha
	3	7.3	O
	4	7.3	J

The variable 084803 S Hydrae also shows irregularity. The minimum seems to have occurred approximately March 1, whereas the calculated date of minimum was April 10.

That wonderfully red star *045514* R Leporis appears to have been close to a maximum the third week in April, the observations of Messrs. Gray and Forsyth seem well in accord considering that the star is extremely difficult to estimate correctly.

Dr. Gray was the fortunate observer of a minimum of 213553 RU Cygni April 16. No date of minimum is given in Hartwig's catalogue for this star, hence the observation has special value.

Messrs. Forsyth and Gray observed a maximum of the variable 213938 RV Cygni during the early part of April, and one of 184205 R Scuti the last of April, when that star attained a brilliance of the fifth magnitude.

Special mention must be made of the observations of the variables 072708 S Can. Min. and 123961 S Urs. Maj., which clearly show the great value of cöoperation in variable star observing.

Nova Geminorum II has been closely followed in its slow decline. Its color changes have been remarkably interesting. On April 13 the Harvard College estimate of its brightness was 6.4, and its color 7 in the photometer on a scale of 0 to 10. It is a pity that this interesting star will soon be too close to the sun to admit of further observations for the time being.

Several of our observers are using the splendid three lens positive ocular made by the John A. Brashear Co. of Allegheny, Pa. This ocular is especially adapted to variable star observing, and all who use it commend the results heartily.

In conclusion all observers are requested to continue to observe the variable 123961 S Ursae Majoris frequently.

WILLIAM TYLER OLCOTT.
Corresponding Sec'y.

Norwich, Conn., May. 10, 1912.

COMMUNICATIONS QUESTIONS AND ANSWERS.

[This department is designed especially for the use of amateurs. Beginners are invited to send in their puzzling questions. The editors will try to see that answers are given to reasonable questions, but will not hold themselves responsible for the correctness of the views expressed in the communications which may find place here. All communications should be brief.]

Peculiar Phenomenon on the Moon.—I deem it a debt to the astronomical world to relate certain phenomena seen by myself on the evening of January 27 (Saturday) 1912. During the time mentioned I had been sighting the moon at half hour intervals. About 10:30 Eastern time I was surprised to see the left cusp showing the presence of an intensely black body about 250 miles long and fifty wide, allowing 2000 miles from tip of cusp to cusp. The appearance was fully as black comparatively as marks on this paper, and in shape like a crow poised.

Of course dark places are here and there on the lunar surface, but not like this. Not to be tedious I will say that every effort was made to eliminate any error of vision or other mistake. I tried at once to phone some Philadelphia astronomer but failed.

At that time I was unaware of Professor Doolittle of the University of Pennsylvania. The object was kept on view till 2 a.m. As the thermometer was at zero I turned in. This object resembled a crow poised as near as anything. Clouds prevented another view till Tuesday following. By that time or sooner it had disappeared, but some sort of disturbance seemed to be still at work. From the time of Pliny such appearances have been peculiar to volcanic eruptions and such seems very probable in this case. I was very sorry to fail in getting in touch with any one qualified to pronounce upon this with authority.

The moon is very tricky and it is very unlikely that anything of this character will be seen in many years or hundreds of years even. I cannot but think that a very interesting and curious phenomenon happened.

Dr. FRANK B. HARRIS.

A Meteor May 30, 1911.—About seven oclock p. m., the 30th of last May, I was standing in my yard facing the west, when a briliiant meteor caught my eye, which I will try to describe, though no words can carry any adequatc picture of it to one who did not see it. It consisted distinctly of a head or nucleus and a long tail. The head about three or four times the apparent diameter of the sun, showed a mass of intensely brilliant streaks and patches of color, much like the effect of a bursting sky rocket, though not at the moment of bursting, for no change of form was visible. Green and red were the most prominent colors. The tail was intensely white and of uniform appearance, except that it paled a little toward the edges, which were distinctly lined against the blue sky. Its cross section was about four times the apparent diameter of the sun, diminishing a little at the end farthest from the head. It extended in what seemed a perfectly straight line, not less than ten or twelve degrees. The meteor's course was due north, as nearly as I could judge, parallel to the horizon, and about twelve degrees above it. It was visible about three or four seconds of time, during which it moved across an arc of about sixty degrees, when it disappeared behind a building near which I was standing. There was no apparent approach to the surface of the earth during the time of its visibility, and nothing would indicate its final destination.

I can best describe the general effect of its appearance by comparing it with other things I have seen. The Alpine glow covering the face of the Jungfrau as seen from Interlaken down the valley is sublime— a wooded hillside, steep and stretching upward and back from the lake five or six miles, seen at the rising of the sun after a cold night, when the frozen mist from the lake has covered every object to the right and the left, above and below, with a frost so thick as to conceal every possible surface of leaf or limb or tree from sight, is an unrivalled inspiration to purity of thought and conduct; a sunset scene on the shore of the lake, when one half of the sky and more is covered with long stretches of red, of gold, of crimson, and of purple, with the spaces between filled with the deepest blue, all so clear and well-defined, above the shimmering lake, as to seem penciled by the Divine Artist, is fixed in memory with indelible colors of magnificence and beauty; but this stately meteoric train steadily moving with perhaps one-fourth the angular velocity of a shooting star, spurning both earth and sky, and aimed at some unknown far-away point in space, and never to be repeated in the experience of one lifetime, will remain as long as earthly memory survives, the most striking emblem of the majestic.

After the above was written I accidentally learned that my friend, Dr. MacDonald Moore, was at the lake and from there saw the same meteoric display, with two important additions. It was evidently a moment after I lost sight of it, and he saw it a longer time than I did, as it passed out over the lake. He saw sparks stream down from the lower line of the tail, and saw the whole pale until it seemed to burn itself out and disappear without changing in the least its height above the water. *Sic transit gloria mundi.* But the memory of it still lives.

F. B. PALMER.

Fredonia, N. Y. Apr. 17, 1912.

GENERAL NOTES.

Remember that the next number of POPULAR ASTRONOMY will not appear until August.

Professor Edwin B. Frost writes that he is giving up the duties of managing editor of the *Astrophysical Journal*, which he has had for the last twenty volumes, and that this work will be carried on by Professor Henry G. Gale, of the department of Physics at the University of Chicago.

Professor Frost expects to sail, with his family, for Europe on the 15th of June, to be gone about nine months.

Professor W. W. Campbell, director of the Lick Observatory, expects to visit the D. O. Mills Observatory, at Santiago, Chile, of which he is also director, during this summer.

Mr. John Tatlock, of New York, has given to Columbia University a collection of astronomical works consisting of 261 volumes and about 1200 pamphlets. (*Science*, May 10, 1912).

The D. O. Mills Observatory.—Mr. Ogden Mills, son of D. O. Mills, has recently made a gift which will be sufficient to support the Observatory during the two years 1913 and 1914, so that the continuance of the extremely valuable work on radial velocities in the southern hemisphere is assured for that length of time.

The staff of the observatory, located on the summit of Cerro San Cristobal, near Santiago, consists of acting astronomer Joseph H. Moore, in charge; Mr. Roscoe F. Sanford, assistant and Mrs. Joseph H. Moore. Mr. George F. Paddock, who for five years was chief assistant at the observatory, has remained on the staff during the current year as a voluntary assistant, making his principal duties the investigation of certain spectroscopic binary stars. (Pub. Astr. Soc. of the Pacific, April 1912).

An Astronomical Fellowship.—There is a vacant Fellowship in Astronomy and Mathematics, available next September at Goodsell Observatory. Candidates should be college graduates who have taken courses in mathematics, including integral calculus, and at least one semester of descriptive astronomy. The stipend is sufficient to meet expenses for room, board and college fees. For further information write to the director of Goodsell Observatory.

A Method of Testing Optical Glass.—It frequently happens that a large object-glass or prism, after going through the long and expensive process of grinding, polishing and figuring, must be rejected because of internal defects in the glass. Not long ago the Solar Observatory received from a celebrated firm in Germany a large prism which was so defective that the D_1 line seen through the upper part of the prism fell upon the D_2 line observed through the lower

part. The figure of the surfaces was excellent, and the whole difficulty lay within the glass. Subsequent attempts to obtain large blocks of glass for prisms have been equally unsuccessful, and as the same difficulty has been experienced with several objectives (including one of 12 inches aperture for the 150-foot tower telescope), the importance of avoiding the loss of time and the expense thus involved is apparent. It would seem probable that the following simple process of testing glass blocks or disks, without giving them a perfect optical figure, must have suggested itself to others. But perhaps it has serious defects which a trial, soon to be made here, will reveal, for I understand that all opticians now complete the figuring of objectives and prisms before they can discover inequalities of structure less obvious than those shown by the polariscope.

Suppose the block of glass to be in the form of a prism, the faces of which may be polished, but not accurately figured.* With the aid of a Zeiss refractometer and some fragments of the prism glass, the index of refraction is measured. The block is then placed in a tank, with two opposite windows of optical glass, the outer face of each a good optical plane, the inner one less perfect. The tank is then filled with a liquid of nearly the same index of refraction as the prism, easily prepared by mixing two liquids of higher and lower indices. Any defects of the prism glass should then be rendered visible with a Michelson interferometer, or by interposing the tank in the path of a beam of parallel light, and applying the knife edge test. If necessary, the liquid may be kept at a constant temperature and stirred during the observations.

If the tank were stably mounted and quite free from vibration, a simple reflecting surface (perhaps even a mercury surface) as its base, returning the light sent vertically downward through the block of glass, might serve in place of the two windows. But in this case the liquid could not be stirred nor the block of glass moved during the test. (George E. Hale, in Pub. Astr. Soc. of the Pacific, Apr. 1912.)

Swedenborg as Cosmologist.—The above is the attractive title of an address delivered by Professor Tansley, of New Church College, London, at the Centenary Meeting of the Swedenborg Society, held in London, in July 1910, and now published in the Transactions of the International Swedenborg Congress. This address brings vividly before us a fact that is too often overlooked or forgotten; viz., that Swedenborg was the pioneer in the enunciation of those modern views as to the evolution of the Solar System that are comprehended under the general name of the nebular hypothesis. Swedenborg's account of the evolution of his *materia prima* from the Infinite appears fantastic to one trained in the methods of modern Science, but his ideas as to the further development of this *materia prima* or rotating nebulous matter, as we may call it, are very remarkable, and worthy of the attention of those members of the Association who are interested in such matters. It should be premised that Swedenborg's *Principia* (the work in which his cosmological views are developed) was published in 1734, Kant's Natural History of the Heavens in 1755, and Laplace's *Systéme du Mond* in 1796. The priority of Swedenborg

* A preliminary test can be made with the rough block, and in any case a polished surface is not essential, though an approximately plane figure is advantageous.

is, therefore, undoubted, and although "every schoolboy knows" that Kant and Laplace are the pioneers in this department of cosmological speculation, I imagine that very few among us realize the position held by Swedenborg in connection with this matter.

I will let two well-known men of science give their views on the subject in their own words, which will serve to emphasize the points mentioned above.

Professor Nyrèn writes:—"It cannot be denied that the essential part of the nebular hypothesis, namely, that the whole solar system has been formed out of a single chaotic mass, which first rolled itself together into a colossal ball, and subsequently, by rotation, separated a ring from itself, which then, during the continued rotation, broke up into several parts, and finally contracted into the planetary masses, was first expressed by Swedenborg. The work of Kant in question, the Allgemeine Naturgeschichte und Theorie des Himmels, was published in 1755, that is, 21 years later. Laplace did not publish his hypothesis until 62 years later. It should further be observed that Swedenborg has, in all probability, given his hypothesis the more correct form, namely, that, as Laplace also later on supposed, the planets were formed out of broken-up rings (on the basis of the vortical theory Swedenborg found but one ring necessary) not, as Kant supposed, immediately out of conglomerations formed from the original mass of vapour." Professor Arrhenius writes:—"If we briefly summarize the ideas which were first given expression to by Swedenborg, and afterwards, although usually in a much modified form—consciously or unconsciously—taken up by other authors in Cosmology, we find them to be the following: (1) The planets in our system originate from the solar matter—taken up by Buffon, Kant, Laplace, and others. (2) The earth—and the other planets—have gradually removed themselves from the sun and received gradually lengthened time of revolution—a view again expressed by G. H. Darwin. (3) The earth's time of rotation, that is to say, the day's length, has been gradually increased—a view again expressed by G. H. Darwin. (4) The suns are arranged around the Milky Way—taken up by Wright, Kant, and Lambert. (5) There are still greater systems in which the Milky Ways are arranged—taken up by Lambert."

In the course of his address, Professor Tansley points out that not only has Swedenborg given us a theory, but he has also illustrated it by a series of drawings (reproduced in the pages of the Transactions), "which imparts a fixity to his conception, and gives a rough idea of that theory of world-formation which still holds a large measure of the field."

My object in writing these lines will have been attained if I succeed in drawing attention to the views of a remarkable personality in a domain of speculation far removed from that with which his name is generally associated.

(A. M. W. Downing in *Jour. Brit. Astr. Assoc.* Jan. 1912.)

The Number of Molecules in a Cubic Centimeter of Hydrogen. As a result of his computations Professor Millikan finds that "there are in a cubic centimeter of gas under normal conditions 2.70×10^{19} molecules, and the weight of a hydrogen atom is 1.735×10^{-24} grams. These numbers can be made more significant to the ordinary reader with the aid of an illustration. If a million men were to be set counting as fast as they could count, say at the rate of 200 a minute, they could count out the number of molecules ian cubic centimeter in just 252 thousand years, if none of them ever stopped to eat, sleep, or die."

The Kinetic Theory of Matter.—In a very interesting and popularly written article in *Popular Science Monthly* for May 1912, Professor R. A. Millikan of the University of Chicago gives an account of the present status of the kinetic theory of matter. "In conclusion" he says "it may be pointed out that not only has it now become possible to prove the correctness of the kinetic theory of matter and the granular theory of electricity, but that, through the results of experiments like the above on the elementary electrical charge, we are now able to determine the exact weight of every atom and every molecule of every known kind of matter, the exact number of molecules in any weight of any substance, the exact value of the kinetic energy of agitation of a molecule, the mean diameter of any kind of molecules, and quite a series of other important physical magnitudes. The first three of these quantities can be found with precisely the degree of accuracy attained in the measurement of the elementary electrical charge, and this is an accuracy of about *one part in a thousand.*"

The Value of Scientific Research.—In the article cited above Professor Millikan puts very tersely and effectively the answer to those who find fault with the spending of large sums of money for scientific research:

"But", says some one, "What of it any way? Does the triumph or defeat of the kinetic theory of matter or the atomic theory of electricity have anything to do with the *practical* problems of the modern world? Is anybody going to be better fed or better clothed because of it?"

The answer is "Within the past seventy-five years—the merest drop in the bucket of recorded time—the conditions of human life on this earth have been completely revolutionized, and that solely because, for the first time in history, man has become interested in considerable numbers, rather than as heretofore in isolated instances, in patiently and persistently seeking merely to uncover nature's 'useless' secrets, and then, when the inner workings have been laid bare, has in many cases seen a way to put his brain inside the machine and drive it where he would. Every increase then in man's knowledge of the way in which nature works must in the long run increase by just so much man's ability to control nature and to turn her hidden forces to his own account."

A Note on Gelatine used in the making of Light-Filters.—The following note taken from a recent issue of "Photographische Rundschau" is given in the *British Journal of Photography* for March 15, 1912. Baron A von Hübl draws attention to the irregularity which may be caused in the making of dye light-filters as a result of impurities in the gelatine used as a vehicle. He recommends the use of iodine as a destroyer of these impurities.

In the preparation of light filters for photographic work it is now almost the universal practice to employ glass plates coated with a solution of gelatine containing dissolved aniline dyes. In doing this it is generally assumed that the gelatine is a perfectly inert body, simply playing the part of the vehicle of the dye. The assumption cannot, however, always be made, since gelatine frequently contains certain impurities which, even when existing only in traces, may yet give rise to quite notable changes in the dyes. These irregularities

are most likely to be felt in the case of the deeper filters, such as the dark yellow light-filters, or the highly selective filters employed in three color work, as also in the compensating filters used for the Autochrome plate.

Perhaps the most important instance is the action of almost all varieties of gelatine on certain azo dyes, as, for example, the "echt-rot D" of Meister Lucius and Brüning. If we add to 6 ccs. of a 6 per cent solution of gelatine 1 cc. of 1:100 "echt-rot" solution, we obtain a purple-red solution which on coating a glass plate, should dry of rose-red colour. Frequently, however, the colour undergoes considerable change on drying and the film finally obtained is brownish-yellow instead of red. Most pure white gelatines, such as the Karl Creutz collotype gelatine and the Winterthür photographic gelatine, show this defect in varying degree, and even the different sheets in a single package will behave differently in respect to this dye.

Besides "echt-rot" a series of other dyes also show distinct reaction with gelatine. For example, "kristal-ponceau" of M. Lumière behaves in a similar way, though to a lesser extent. Pheno-safranine, napthol-green, filter-blue and tartrazine are somewhat bleached, whilst films of filter-yellow become perceptibly darker.

A series of experiments has shown that this characteristic of gelatine is apparently conditioned by the presence of traces of sulphites. The substances, it should be said, can scarcely be recognized by tests of the gelatine, but the assumption is confirmed by the fact that the disturbing impurity can be rendered innocuous by addition of oxidising substances. It is clear that the impurity is a relatively unstable substance, for it is found that the quality of the gelatine improves if it is allowed to stand for a considerable time (24 to 48 hours) as an emulsion, or in the semi-swollen state in cold water. Also the storage of the gelatine when in the solid state appears to act favorably, whilst on the other hand, the sheets of gelatine taken from the middle of the packet appear to exert a considerable stronger bleaching action.

Such an impurity as this in gelatine is readily possible since aqueous solutions of sulphurous acid are frequently used, not only for the treatment of the glue from the bones, but also as a purifying and bleaching substance in the conversion of the crude glue into gelatine.

A radical means of rendering such a gelatine serviceable for the preparation of filters consists in the addition, before incorporating the dyes with the gelatine solution, of a little iodine tincture—about .5 to 1 cc. of 1:100 iodine solution—to 10gms. of dyed gelatine. This proportion of iodine is amply sufficient as a rule: in certain cases it may perhaps be not quite enough, and it is, therefore, well to test the gelatine solution before use as regards its effect on the dyes. For this purpose the test portion is stained as above described with "echt-rot," the solution flowed on to a glass plate and put to dry. If the film is of clear rose-red colour the use of the gelatine may be proceeded with, but if on the other hand, the dry film shows a brownish-yellow colour, a further slight addition of iodine tincture should be made and the test repeated.

As regards the preparation of filters with very strict absorptive qualities the results are extremely uncertain when working with the gelatines ordinarily found in commerce. For example, an Autochrome filter prepared with filter-yellow and "echt-rot" may turn out to be brownish-yellow instead of orange, and, using for such filters the dyes filter-yellow and kristal-ponceau, etc., a red colour of very different character is obtained, in spite of the most scrupulous precautions and adherence to the formula, according to the quality of the gelatine.

The use of the iodine process given above may, therefore, be recommended to all: from such simple tests as those described, any one may discover whether the gelatine employed for light-filters is in any way open to suspicion for the reasons described.

A. von Hubl.

Theoretische Astronomie, by Dr. W. Klinkerfues, new (third) edition by Dr. H. Buchholz, XXXVIII + 1070 pp. From the press of Friedr. Vieweg & Sohn, (1912) Braunschweig, Germany.

In 1870 Professor W. Klinkerfues, director of the Royal Observatory at Göttingen, published his *Theoretische Astronomie.* This work was characterized by a fine literary and mathematical style, and these qualities won for it wide use and caused it to have a strong influence on this branch of astronomy. At about this time two other very excellent works on the same subject were also published, viz., *Theoretical Astronomy* by Watson, and *Lehrbuch der Bahnbestimmung der Kometen und Planeten* by von Oppolzer. It is remarkable that nearly seventy years should elapse after the publication of *Theoria Motus* by Gauss before a new work should appear on the subject, and then that almost in the same year three such excellent treatises should be published.

The original work of Klinkerfues was not so extensive as those of Watson and von Oppolzer. Its treatment of the fundamental problems of parallax, aberration, precession and interpolation, as well as the details of the Keplerian motion, was much less complete than those given in the books of Watson and von Oppolzer. The problem of special perturbations, and therefore of the determination of definitive orbits in the strictest sense, was entirely neglected. In order to supply these deficiencies, and at the same time to retain that which Klinkerfues had given with such rare elegance, a new and enlarged edition of the Theoretische Astronomie was brought out by Dr. Buchholz in 1899. The work under review is a new and thoroughly revised and enlarged edition, also by Dr. Buchholz.

The present edition of Klinkerfues' *Theoretische Astronomie* contains nine divisions, or chapters, and two appendices. The first chapter is devoted to the two-body problem and the computation of ephemerides. In it appears much material added by Dr. Buchholz which was not in the first edition. More than a hundred pages are devoted to parallax, precession, etc. The second chapter contains the theory of the determination of the elements of circular orbits. The third is devoted to the determination of parabolic orbits of comets. The method is that of Olbers and is developed in great detail and illustrated by numerical examples. The fourth chapter of 173 pages treats of the determination of elliptic orbits. The first part of the chapter is devoted to the methods of Gauss, with the modifications introduced by Hansen; and the last part gives the methods of Gibbs and Leuschner. Illustrative examples of the details of the computations are given. For the first two methods they are incorporated in this chapter, but for the method of Leuschner a number of examples, illustrating a variety of special cases, have been worked out by Professor Crawford, and are given in the second appendix, together with summaries of the formulæ to be used in the computations. The fifth chapter contains a discussion of the determination of elliptic orbits from four observations, only two of which are complete. Chapter six is devoted to mechanical quadratures and special perturbations; chapter seven to the determination of

an orbit from many observations by the method of least squares; chapter eight to the computation of double star orbits, and chapter nine to the orbits of meteors. The first appendix contains all the usual auxiliary tables used in the computation of orbits, and an extension of one of von Oppolzer's tables by Leuschner.

It is evident from the summary of the contents which has been given that the book is an exhaustive treatise on the subject to which it is devoted. It is a pleasure to record that it is exceptionally clearly written, and that extraordinary efforts have been made to get it free from errors. It is too much to hope that it is absolutely free from mistakes, but they must be very few. The typography is excellent and approaches the high standards which the French often attain. Dr. Buchholz is to be congratulated on getting out a treatise on theoretical astronomy which, because of its scope, clearness, accuracy, and inclusion of modern methods, leaves little to be desired. But for the trained mathematician it is too detailed, and the train of thought is lost in the mass of transformations and formulae. It would have been well, I think, to have given some such general summary of principles and comparison of methods as Poincaré has written, or more recently Charlier, in an excellent series of papers.

It is needless to say that the book is in the German language. The English speaking person who reads it will get an increased respect for the possibilities of forming compounds from German words, and will be ready to believe there is no limit to the length they may attain. A good example is the word Aequatorealhorizontalparallaxenwinkels.

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Meteorology.—A Text-book on the Weather, the Causes of its Changes and Weather Forecasting, by Professor Willis Isbister Milham, Ph. D., Professor of Astronomy in Williams College, published by the Macmillan Company (1912). Price $4.50.

The book is a resumé of material gather by its author, and issue by him for a number of years in a course which he has offered in meteorology. The author claims no attempt at completeness in the treatment of the subject, but rather that his book is a "presentation of the present state of the science" and an introduction to further study.

Each chapter is carefully outlined, many practical exercises are suggested, and full lists of references for further study are given. One of the striking characteristics of the book is the richness of illustration of the topics treated, by the use of photographs, discriptions of apparatus, tables, graphs, diagrams and maps, comparisons and examples. The chapter on "Pressure and Circulation of the Atmosphere" is, as the author points out, an excellent illustration of the application to scientific subjects of inductive and deductive methods of reasoning. First, instruments for determining pressure, distribution, and motion of the air explained, tables and graphs are given to show the results of observations, and some generalizations are made. Then, on the other hand, the general scientific principles are stated and conclusions drawn as to what the pressure distribution, and motion of the atmosphere of the earth should be under the operation of these laws. Deductions from the principles are then shown to be in exact agreement with the generalizations derived from observations.

In the appendices are given comparisons of thermometric and barometric scales, a full bibliography on meteorology, and sets of maps showing various meteorological conditions.

Professor Milham's book is an excellent text on meteorology and a good reference book. The author has combined very happily a scientific and a popular treatment of the subject, making a text that is, at the same time, accurate and very readable.

A Beginner's Star-Book, by Kelvin McKready, vi + 148 pages, published by G. P. Putnam's Sons, New York and London.

This is an excellent book for the beginner who wishes to take up the study of astronomy by himself. It is splendidly gotten up, printed entirely on fine plate paper, and profusely illustrated with photographs taken recently at the Yerkes, Lick, Lowell and Mt. Wilson observatories. For constellation study there are twelve pairs of maps, one of each pair printed with the stars in white on a black back-ground, the other with the stars in black on a white back-ground. On the latter the outlines and names of the constellations and the letters designating the stars are printed. There are several well printed photographs of the planets Mars, Jupiter and Saturn, and of the great comets of recent years.

The book could be very effectively used for supplementary work in many classes in astronomy. The publishers will be glad to forward, upon request, the volume itself for examination, to instructors and professors.

History of Astronomy, by George Forbes. G. P. Putnam's Sons, New York and London. The Knickerbocker Press, 1909.

The book is one of a series of monographs, of about two hundred pages each, presenting accounts of the development of the great divisions of science. It is a brief account of the history of astronomy from its beginning down to modern times, but makes no attempt to deal with the untested hypotheses of the men who are still "making history in astronomical work." The book can not be better summarized than in the authors introduction. He has given to the reader "in a limited space enough about each age to illustrate its tone and spirit, the ideals of the workers, the gradual addition of new points of new means of investigation."

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